SCIENTIFIC AMERICAN SUPPLEMENT No. 820

Copyright by Munn & Co., 1891.

Scientific American Supplement, Vol. XXXII. No. 820.
Scientific American, established 1845.

NEW YORK, SEPTEMBER 19, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

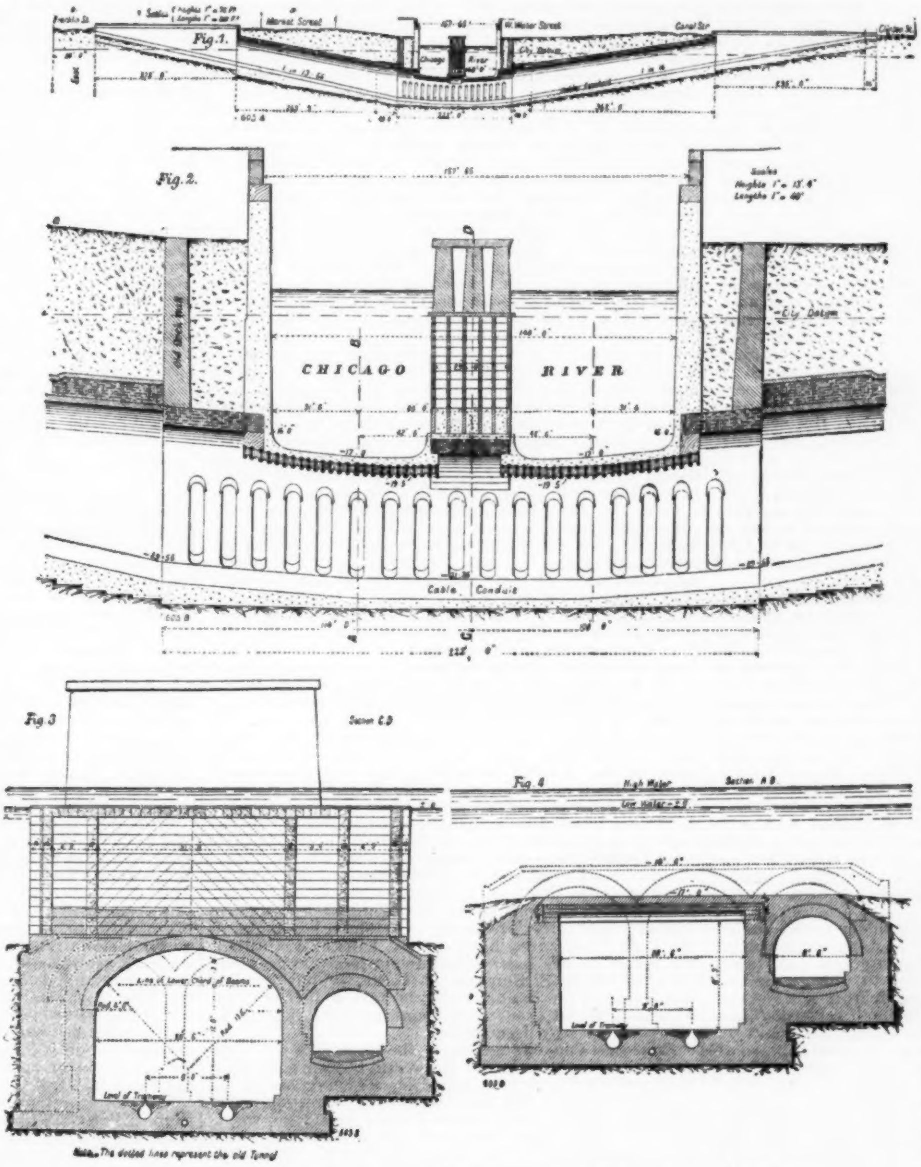
THE WASHINGTON STREET TUNNEL.

THE Chicago River and its branches constitute the harbor of Chicago, where all the business of the port by Lake craft is transacted. The arrivals and departures of vessels have reached the enormous aggregate of over 22,000 annually in a season of navigation of about seven months, making Chicago the first port in the United States as far as the number of arrivals and departures is concerned. Along this river are great lumber and coal yards, grain elevators, meat packing establishments, and generally all the means and appliances and paraphernalia of the great commerce by lake centering at Chicago, as well as facilities for transfer from rail to water transportation. The main river and its south branch cut off the business center of the city from the populous north and west sides, and it requires the most careful management by the city officials to accommodate the streams of pedestrians and vehicles and the passing vessels. The opening of a bridge blocks up the streets for long distances, and at certain hours of the day vessels are detained by closed bridges.

This great inconvenience, in spite of quick turning bridges, is daily becoming more burdensome and annoying to both land and marine interests, and means are eagerly sought to reduce this annoyance, even at a great expenditure of money. Besides the swing bridges, there are two traffic tunnels under the river, and a third one for street car service in progress of construction. The Washington street tunnel illustrated was built in 1869, at a cost of 512,700 dollars, and is 1,525¼ feet long. The bed of the river and the top of the masonry of the river portion are the same, but unfortunately it was built at that time to allow of but 14 feet depth at low water in the river; this depth has always been insufficient, and the tunnel, on this account, was a serious obstruction in the river.

A few years ago the West Chicago Street Railway Company got permission from the City Council to operate its cars through the tunnel, on condition that the level under the river should be lowered so as to have at least 17 feet of water over it at the lowest stage, or 19 feet at mean water, and also that they build a masonry center and end piers over the tunnels to accommodate a swing bridge, the city supplying the superstructure. Mr. S. G. Artingstall, engineer, of Chicago, was intrusted with the work, and it was completed in the spring of 1890. For the river section one-half of the stream was closed by a cofferdam, the timber crib which was to serve as the foundation for the masonry center pier serving as the head of the cofferdam; when this was pumped dry of water the arch of the old tunnels was taken up and a cover for the tunnels built with steel girders 20 inches deep and 2½ feet centers, with brick arches between the girders in four rings of brick, covered with a layer of asphalt and then with 12 inches in thickness of cement concrete. This girder construction was adopted because it required the least amount of lowering of the roadway of the tunnel, while at the same time the necessary depth of water was obtained in the river. For the portion under the crib for the center pier, and also under the dock walls or end piers, a three-centered arch, built with five rings of bricks, was adopted. The part under the center pier was built by the usual methods of tunneling under the cofferdam. This part has not only to serve the purpose of a roof over the tunnels, but also is now supporting the masonry center pier and swing bridge. The approaches and all parts of the tunnel at the time were put in thorough repair, the grade of roadway under the river lowered to correspond with the lowering of the roof and the grade of approach changed. The illustrations, Figs. 1 to 4, show the character of the work. The dotted lines show the old tunnel before work was commenced, and the shaded lines the structure as it now exists.

The West Division Street Railroad Company are now building under the Chicago River, about ¼ mile south of Washington street, a tunnel for the exclusive use of their street cable cars. This work is being done under the direction of Mr. Artingstall, who is now chief engineer of the sanitary district of Chicago, and it is expected will be finished in the fall of 1892. The dimensions of the tunnel are very large, as the company are sparing no expense to make it light, airy, and pleasant for their passengers. The tunnel is 30 feet clear width inside by 16 feet high, and besides passing under the river, goes under two seven-story buildings and one five-story building, and also under all the railroad tracks entering the Union Depot. A large portion of this tunnel is built, and the part under the tracks is in process of construction; the tracks have been undermined and supported without interfering with the passage of a single train. The cost of this tunnel will be about $2,250,000.—*Engineering.*



Note.—The dotted lines represent the old Tunnel.

THE WASHINGTON STREET TUNNEL, CHICAGO

A REVIEW OF MARINE ENGINEERING DURING THE PAST DECADE.*

By Mr. ALFRED BLECHYNDEN, of Barrow-in-Furness.

THE institution has previously had two papers dealing with the progress of marine engineering—that by Sir Frederick Bramwell, read at the meeting in this city in 1872; and that by Mr. Francis C. Marshall in 1881. The writer purposes now to review briefly the progress from the latter date until the present time.

The results of Mr. Marshall's investigations were briefly that the type of engine then employed was the two-stage expansion compound; and from a series of examples of performances of such engines he found that in long sea voyages, on the average the boiler pressure was 77·45 lb. per square inch, the piston speed 467 feet per minute, the heating surface per indicated horse power 3·99 square feet, and the consumption of coal per indicated horse power 1·828 lb. per hour. No mention was made by him of the three-stage expansion engine, although at that time at least two had been constructed, and had worked successfully for seven years. These were the engines of the Propontis, with cylinders 23 inches, 41⅛ inches, and 62⅛ inches diameter, by 42 inches stroke, constructed by Messrs. John Elder & Co., to the designs of Mr. A. C. Kirk; and those of the Sexta, constructed at the Ouseburn Engine Works, Newcastle-on-Tyne, to the specification of Mr. A. C. Franklin, then of London, with cylinders of 11 inches, 17 inches and 24 inches diameter, by 18 inches stroke. Both of these engines were commenced in the year 1873, and tried in 1874, and were of the three-crank type usually built now. Since 1881, the three-stage expansion engine has become the rule, and the boiler pressure has been increased to 160 lb. and even as high as 200 lb. per square inch. Four-stage expansion engines of various forms have also been adopted; and many changes have been made in other respects, necessitated by increased pressure or by desire for increased economy or power. In dealing with the changes made during the last ten years, it will be best to commence with the furnace, and to proceed from the boiler to the engine.

Forced Draught.—Ten years ago the principle known as forced draught, so far as marine engineering in this country was concerned, had been practically confined to torpedo vessels, and the writer believes to three cruisers, each of about 2,850 horse power, although it had long been employed in steamers on American waters. Since then it has become the rule in all vessels for naval service, and comparatively common in both passenger and cargo vessels. By this means it is possible considerably to augment the power obtained from a given boiler; and, so long as it is kept within certain limits, it need result in no injury to the boiler, but when pushed too far the increase is sometimes purchased at considerable cost. There are several methods by which the principle may be practically applied. In the earlier cases in this country closed stoke holds were adopted, the air being delivered into them by fans, at a pressure varying from about 1 inch to 3 inches of water. This arrangement certainly has the merit of keeping the stoke holds cool, and its details are simple; but it is dirty, and where bunker doors are not well fitted, great discomfort may be caused on deck. Possibly also it is not quite so economical as the closed ashpit system; but such exact data as exist of its working indicate that with moderate air pressure it is at least no less economical than natural draught.

In America it was customary to close in the ashpits, and take the delivery tubes from the fans into them. This, though involving more ashpit fittings, is certainly advantageous so far as cleanliness is concerned; the furnaces are also not subjected to the severe strains caused by the inrush of cold air which occurs during firing with closed stoke holds. As often fitted it has the disadvantage of making rather a hot stoke hold, though with sufficient precautions there is no reason why the ventilation should not be made perfect by taking the air through the stoke holds. In the earlier American experiments the air was introduced into the ashpits by pipes at their back ends. The principle of forced draught has also been carried out by placing a fan in the uptake, and exhausting through the furnaces. This plan has the great advantage of dispens-

* Paper read before the Institution of Mechanical Engineers, July 28, 1891.

ing with the elaborate furnace fittings common to the undergrate systems; and according to the researches of Dr. Tyndall on combustion in condensed and attenuated atmospheres, it should result in a more perfect combustion, but how far this is realized in practice has not come within the writer's experience. In regard to the economy of forced draught, while the mean consumption of coal in steamers working under natural draught is 1·573 lb. per indicated horse power per hour, it is only 1·336 lb. in those fitted with forced draught. This is equivalent to an economy of 15 per cent. Part of this economy, however, may be due to the other heat-saving appliances with which the latter steamers are fitted. But independently of the economy of forced draught in coal relatively to power, it is, like all economies in marine engineering, simply a question of the comparative cost of carrying a given freight at a given speed; in other words, it is a question of the total expenses of carrying the freight with the help of forced draught, as against the total expenses with natural draught. It is not a mere matter of coal consumption, which is only one of the elements that go to make up the total. Assuming that the consumption of coal per horse power is not less with forced than with natural draught, then, since with forced draught it is possible to develop a given power from a smaller boiler and consequently with a smaller weight than with natural draught, here is at once a source of economy, because the difference in weight may be made up in freight. Such evidence as exists shows that not only is forced draught more economical as regards the quantity of coal, but by its means such classes of coal may be used as would not without it be worth putting on board. It is in this direction, perhaps, that the greatest saving has followed its employment.

Thus far the following would appear to be a fair summary of the advantageous points attending the use of forced draught. First it seems fairly well established that, if the boilers are well constructed and are provided with ample room to insure circulation, their steaming power may without injury be increased to about 30 or 40 per cent. over that obtained on natural draught for continuous working, and may be about doubled for short runs. Secondly, such augmentation is accompanied in normal cases by an increased consumption per indicated horse power; but, thirdly, the same or even greater power being indicated, it may with moderate assistance of forced draught be developed with a smaller expenditure of fuel, the grates, etc., being properly proportioned. Fourthly, forced draught enables an inferior fuel to be used; and fifthly under certain conditions of weather, when with normal proportions of boiler it would be impossible to maintain steam for the ordinary speed with natural draught, the normal power may with forced draught be insured. In particular cases any or all of these advantages may be a source of economy; and the first of them may render possible that which would otherwise be impracticable. As now adopted in the navy, forced draught is purely an auxiliary intended for use under special circumstances. When a maximum power and speed are required only occasionally, or when the vessel is intended ;for cruising in hot climates, or under such conditions of weather as to impair the natural draught power, in such cases it is a most important source of economy. Vessels of the cruiser type, which are required in a case of necessity to develop say over 9,000 horse power, while the usual cruising speed of about 10 or 12 knots requires only from 1,000 to 1,500 horse power, are rendered possible at a reasonable cost by the adoption of forced draught.

The recent troubles with naval machinery in vessels of the Barracouta class have done much to unsettle opinions in regard to this problem. But looked at calmly it becomes evident that the causes of those troubles are altogether apart from the question of forced draught pure and simple, and are rather questions of boiler design. So long as boilers were designed with ample spaces for internal circulation, ample capacity of furnace and combustion chamber, and so proportioned that the surfaces of the furnaces and combustion chambers were sufficient to absorb a large proportion of the heat before the products of combustion reached the tubes, and above all so that the tube plates were protected from direct impact of the intense radiant heat from the incandescent mass of the fire, no serious trouble ensued. In the recent cruisers built under the Naval Defense Act of 1889, a separate combustion chamber to each furnace has been adopted with perfect success.

Boiler.—It is impossible to chronicle much change in the form of the marine boiler as designed for ordinary service; but both Messrs. Thornycroft and Messrs. Yarrow have given their attention to water tube boilers, with the object of lightening weights and so rendering higher speeds attainable in small vessels. These boilers doubtless have the merit of lightness; but unless there are no fewer than two in one ship, so arranged that one boiler can readily be shut off, they can be of little use in ordinary service, as the failure of one tube is the failure of the boiler of which it is a part; whereas in an ordinary boiler a tube may give out, and cause no more trouble than that involved in inserting a stopper. If, however, tubulous boilers were used in numbers and separable, they might be made serviceable for the mercantile marine, and might give the shipowner a few more tons dead weight, and so make remunerative what might otherwise be a loss. One of the great advantages, however, of boilers of this type, namely the small weight of water they carry, is attended by what might be a serious drawback, inasmuch as they have to be fed and worked with greater care; whereas the large cylindrical boiler, which contains a large reserve of water, will admit of a little irregularity. But to set against this there is the probability that the damage might not be so serious in the water tube boiler if the water were allowed to become low. Moreover, by the use of slow-working independent feed pumps there is no reason why this possible source of trouble should not be overcome. Though no particular change can be recorded in the general design of the marine boiler, the change of material used and the great advance which has taken place in the application of tools to boiler making cannot pass without notice. As a material for boilers, iron is now a thing of the past, though it seems probable that it will continue yet awhile to be the material for tubes. Steel making has moved on apace, so that now plates can be procured of 132 square feet superficial area and $1\frac{1}{4}$ in. thick. Mechanical appliances have been greatly improved. All flanging, tapping, tubing, and staying, and in some works practically all riveting, is the work of machines; and a practical calking machine seems not quite an improbability. On the other hand, for purely boiler work, a punching machine has happily become obsolete in marine engine works. In view of these facts and of the ever-increasing knowledge of the structure, the Board of Trade and Lloyd's have relaxed some of the rules by which manufacturers were "guided," if not perhaps somewhat hampered; and have made considerable modifications in their scantlings. It is questionable, however, whether these bodies might not with safety still further modify their rules, and reduce the thickness of shells, and lower the tests relatively to working pressures. For some years past boilers have been built for the Royal Navy with shells 18 per cent. thinner than required by the Board of Trade and Lloyd's rules, and the test pressure, instead of being double the working pressure, is only 90 lb. above it; and these boilers have proved perfectly satisfactory in respect of strength. While 18 per cent. lighter, it must not be supposed, in the case of thick plates at least, that they are weak in proportion; because the difficulties of manufacture and probabilities of defects in the plates increase so rapidly with thickness that it is doubtful whether the difference of weight represents with any degree of approximation the difference of strength. This appears to be the view of the Board of Trade, whose rules require all heavy plates to be subjected to special tests. This subject was introduced by Mr. Richard Sennett at a meeting of the Institution of Naval Architects in 1888; and Mr. John Scott, of Greenock, liberally taking action in the matter, subjected to hydraulic pressure a boiler shell built to Admiralty requirements, with the result that he proved with sufficient clearness that the elastic strength of the structure was capable of standing at least double the working pressure for which the boiler was designed. Without further discussing this question at the present, it appears to the writer that the time has arrived when the Board of Trade and Lloyd's should reconsider their rules in these respects.

The increased pressures of steam have also caused attention to be directed to the furnace; and have led to the adoption of various artifices in the shape of corrugated, ribbed, and spiral flues, with the object of giving increased strength against collapse without abnormally increasing the thickness of the plate. As is well known, a thick furnace plate is viewed by many engineers with great suspicion; and meanwhile the advisers of the Board of Trade, perhaps with great wisdom, have fixed the limit of thickness for furnace plates at $\frac{5}{8}$ inch; but whether this limitation will stand the light of prolonged experience remains to be seen. It is a fact generally accepted that the conditions of the surfaces of a plate are far greater factors in its resistance to the transmission of heat than either the material or its thickness. In;1878 the writer made a number of experiments on the transmission of heat through brass and iron boiler tubes, the results of which went to show that, just so long as the surfaces were perfectly clean, the brass tubes were considerably more effective; but immediately they were reduced to the ordinary working condition of boiler tubes there was no appreciable difference in their efficiency. In 1867 Isherwood tried experiments with plates of $\frac{1}{8}$-inch, $\frac{1}{4}$-inch, and $\frac{3}{8}$-inch thickness; and he found that the thickness made no difference in the result, so far as he was able to detect. From the measured rate of the transmission of heat through thin plates and along bars of metal, it has been estimated that the resistance of the surfaces when fairly clean is about $97\frac{1}{2}$ per cent. of the whole for a $\frac{1}{2}$-inch steel or iron plate; so that, granted a plate free from lamination, thickness being a mere secondary element, it would thus appear that a furnace plate might be increased from $\frac{1}{2}$-inch to $\frac{3}{4}$-inch thickness without increasing its resistance more than $1\frac{1}{4}$ per cent. So convinced have some engineers become of the soundness of this view that they have adopted flues $\frac{3}{4}$ inch thick. Among those who have had the courage to take this step is Mr. Alexander Taylor, of Newcastle-on-Tyne, who reports that after five years' work such flues have given unqualified satisfaction. In the matter of mere size, there has not been much increase over boilers made many years ago; on the contrary, the increased pressures adopted have tended to cause a reduction in size. It is questionable whether such large boilers as those of the Wyoming and Wisconsin will ever again be produced. On the other hand, as the higher pressures have caused thicker scantlings, the larger boilers have become very heavy. The boilers of the R. M. S. Empress of India, which were 16 feet 3 inches in diameter by 19 feet 6 inches long, weighed 85 tons each, without furnace fittings or mountings of any description.

Engine.—The change from the principle of two-stage expansion to that of three and of four stages has been attended with corresponding modifications in the engine. Though the first two of the three-stage expansion engines were of the three-crank type which has now become the standard, yet in the earlier east coast engines which were introduced by Mr. Alexander Taylor in 1881, the engine was simply the two-crank engine with another high pressure cylinder added tandem to the first cylinder; and for a year or two favors seemed divided between the three-crank engine and the two-crank tandem, the first cylinder being tandem sometimes with the second and sometimes with the third. In recent years the tandem triple seems to have disappeared, except in cases of tripling old engines. But perhaps the desire to economize in length of engine has given rise to more varieties of arrangement than any other single cause. For this purpose, combined with the aim of making them more accessible, the valves have been removed from the fore and aft center line, and placed behind or in front, and worked either by one of the numerous forms of radial valve gear or by the link motion and levers. It is true that by such an arrangement the length over the cylinders can be diminished; but as the extent to which the distances between the centers can be reduced is limited by the lengths of the shaft bearings and the thicknesses of the cranks and couplings, little can be gained below the cylinders by this means. However, where length of hatch is important, such an arrangement has its value. Of four-stage expansion engines, the oldest type is that made by Messrs. Denny and by the Barrow Shipbuilding Company, which consists simply of two pairs of cylinders working tandem. Messrs. Richardson, of Newcastle, adopt a four-crank engine. Messrs. Fleming & Ferguson's consists of two pairs of cylinders working two cranks by means of a pair of triangular frames; this is similar in principle to Mr. Bernays' engine illustrated in the discussion upon Mr. Thornycroft's paper on high-speed steam navigation.* Two of the most common types of triple engines are those with the cylinders arrranged in the sequence—high, intermediate, low; the condenser forms part of the engine framing, and the pumps are placed at the back of the condenser, and worked by levers. In the smaller engines, the cylinders are rigidly bolted together; but in the larger they are free, and connected only by a pair of bar stays fixed to their centers. This is customary in order to prevent the extension of the distance between the centers when the engines are heated; but it is a point which appears more important in theory than in practice, and it is doubtful whether the greater rigidity of the bolted cylinders in the smaller engines is not a much more important feature in ordinary work.

In the navy, where, owing to the necessity for arranging all machinery below the water line in unprotected vessels, the horizontal engine formerly reigned almost supreme, vertical engines are now almost uniformly adopted, and the necessary protection for the cylinders is obtained by an armored hatch. In the later designs the larger engines are made open fronted, with standards of cast steel at the back and wrought steel pillars in front. Feed, bilge and circulating pumps are worked by separate engines. For the air pumps also separate engines have sometimes been adopted, and they possess great merits for maneuvering purposes, as the vacuum can be maintained and the condenser kept clear of water while the main engines are standing, and the latter are thus ready to answer more instantly any order which may be given. With the three-crank engine, however, this is of less importance than with the two-crank type. In modern cruisers, which are designed with the view of steaming upon emergency at a very high speed and ordinarily at about half that rate, the engines become much too large for the power developed at slow speeds, and in consequence are not economical under the ordinary condition of working. In larger vessels this difficulty is met by separating each set of propelling engines into two sets of half the capacity, the one forward of the other, and so arranged that the forward set may be disconnected and the after set left to do the work. The propelling engines of the Italian cruisers Lepanto, Italia, Re Umberto and Sardegna, and of the British cruisers Blake and Blenheim, have been arranged on this plan. In smaller cruisers no such plan has been adopted, so far as the writer knows, nor would it be convenient with the limited room available; but something almost equivalent might without much difficulty be contrived, such as using the high and intermediate cylinders as a two-cylinder compound engine, and disconnecting the low-pressure cylinder, which would require to be placed forward. The general details of the engine have not undergone many modifications, but still they have not remained without change.

Piston Valves.—In Mr. Marshall's paper piston valves were referred to. Since higher steam pressures have become common, these valves have become the rule for the high-pressure cylinder, and are not unusual for the intermediate. When well designed they have the great advantage of being almost free from friction, so far as the valve itself is concerned. In the earliest piston valves it was customary to fit spring rings, which were a frequent source of trouble and absorbed a large amount of power in friction; but in the writer's recent practice it has become usual to fit springless adjustable sleeves. For this plan he is indebted to the suggestion of Mr. James Thompson, of the Pacific Steam Navigation Company. These sleeves have all the advantages of the solid ring, so far as their freedom from friction is concerned; and in case of leakage they can with ease be adjusted by lining up at their joints. In smaller engines the same springless ring has been used for the pistons of the high-pressure and intermediate cylinders. It may not give such absolute steam tightness as the spring ring; but any little leakage can be picked up in the low-pressure cylinder, and such very slight loss of efficiency as may be due to this cause should be fairly well compensated by the diminished friction of the valves. For low-pressure cylinders the writer is not much in favor of piston valves: if fitted with spring rings their friction is about as great and occasionally greater than that of a well-balanced slide valve, while if fitted with springless rings there is always some leakage, which is irrecoverable. But the large port clearances inseparable from the use of piston valves are most objectionable; and with triple engines this is especially so, because with the customary late cut-off it becomes difficult to compress sufficiently for insuring economy and smoothness of working when in "full gear," without some special device.

Valve Gear.—This subject has received much attention. About 1880, Messrs. R. & W. Hawthorn, the firm with which the writer was then connected, commenced the use of a form of the Hackworth valve gear, of which some modification was fitted to nearly all of their subsequent engines. About the same time Mr. Joy introduced his valve gear, which is nearly if not exactly the same in principle as one of the numerous forms tried by Mr. Charles Brown. The apparent and direct advantages were: more nearly mathematically accurate distribution of steam, constant lead, and fewer parts. Indirectly these valve gears have the advantage of shortening the engine, over the cylinders at least, because in their adaptation to the engine the valves are removed from the center line to the front or back, whereby also they are rendered more accessible. These advantages having turned attention to the matter, the forms of radial valve gear became "legion." But the old fashioned link motion, though it seemed for a time likely to disappear, still holds its own, and in all probability will continue to do so. In the distribution of steam it may not be so mathematically accurate on paper; but practically the effect is, or can be made, as good as with the best radial valve gear. It does not give constant lead when linking up; but constant lead is not the ideal of perfect valve setting. A constant lead angle of the crank is more nearly what is required,

* Proc. Inst. Civ. Engineers, vol. lxvi., page 147.

for which a diminishing lead in the valve with linking up is the necessary condition. The old link motion lends itself readily and gracefully to any modifications which may be suggested by changes in the condition of working; the radial forms do not. Besides this, the link motion admits of simple geometrical treatment, which is generally understood even in the engine room, and is consequently a safer arrangement in the hands of the men found there. For high speed engines the writer has strong objections to radial valve gear, as to any motion not the most direct possible. It is true such gears are frequently fitted to high speed engines; and in some horizontal engines for the navy, where space was an element of importance, they become almost a necessity. But the sudden shocks to which the parts are subjected are liable to cause considerable spring in the levers of which such gears largely consist; and hence in some engines so designed the readings of valve settings are no guide as to what occurs when the engines are at work. Though this may be overcome by adding weight to the parts, yet when made sufficiently strong to be perfectly satisfactory the writer ventures to say that the link motion will be the lighter of the two.

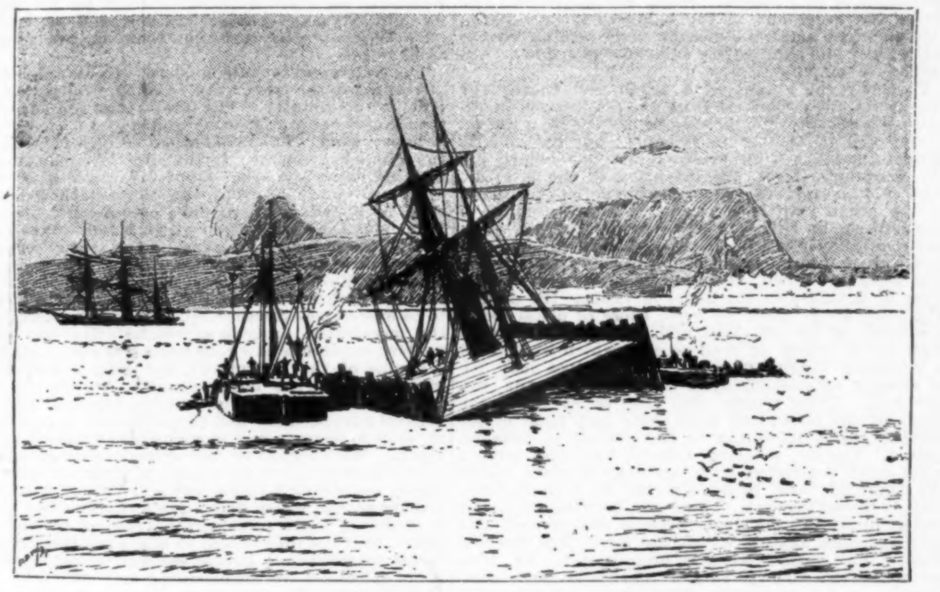
Crank Shaft.—For ordinary mercantile ships the solid crank shaft has become a thing of the past. As now built up of separate pieces shrunk together, the crank shaft is sounder and far more reliable, though it is a little heavier.

Centrifugal Pumps have been more commonly adopted than formerly for circulating purposes, and with great wisdom, as they offer the advantage of keeping a cool condenser at all times, and may be used as a powerful auxiliary in case of bilging.

(*To be continued.*)

THE RAISING OF THE UTOPIA.

THE steamship Utopia, which sank on March 17, in about seven fathoms of water, after striking the ram of the battleship Anson, in the Bay of Gibraltar, was successfully raised July 8. The operation was carried out by the East Coast Salvage Company, of Glasgow, who raised the vessel by means of coffer dams, erected on a superstructure of timber, built round the vessel to the surface of the water. Fourteen thousand cubic feet of timber and fifty tons of iron were used in its construction. The water was pumped out of the Utopia by six centrifugal pumps, and as the vessel rose she was towed toward the shore and finally beached.—*Daily Graphic.*



THE RAISING OF THE UTOPIA.

[Continued from SUPPLEMENT, No. 819, page 13083.]

MUSICAL INSTRUMENTS: THEIR CONSTRUCTION AND CAPABILITIES.*

By A. J. HIPKINS, F.S.A.

Lecture III.

HAVING described in the previous lectures those musical instruments (whether string, pipe, or reed) which belong to such combinations as the orchestra and military band, we will now consider those furnished with keyboards, by which they are manipulated; and, as this contrivance originates a fresh order of treatment, I have decided to group keyboard instruments as a separate class. Without the keyboard, music, in its modern European development, would hardly have been known, the orchestra might not have progressed beyond the Hungarian gypsy band, and there would have been no organ to aid religious service, or support choral masses in harmony; and the facilities for the composer the pianoforte offers would have been wanting. Indeed, there can be no doubt that the keyboard, by the privilege it gives for the trial of several voices or parts, has helped to build up counterpoint, and, ultimately, harmony.

Before proceeding to the various instruments that are accessible, by the keyboard, to full harmony in any combination of notes, it will be well to consider the keyboard alone, and to try to make out its history. Like all inventions that have required time for their recognition, and an ever-widening use to bring out their importance, the record is imperfect, and the materials fragmentary, that can throw light upon its development. Its origin was either in the organ, when an aggregate of pitch pipes only, or in connection with the monochord, the normal mediæval pitch measure. It is accepted that organs, hydraulic or otherwise, existed in the time of the Roman domination, and may have been of Greek invention. In the eighth and ninth centuries organs were heard of in England, France, and Germany; but up to the eleventh century, there appears to have been no use made of balanced levers or keys to produce the notes. Sliding rods, like modern drawstops, seem, from the imperfect notices existing, to have been the only means for obtaining and controlling sound from the pipes. As single notes only were practicable, there could have been no harmony whatever, unless two persons, drawing out slides simultaneously, could have set two notes going. There are three ways open to us to trace historically the construction and improvement of musical instruments, or whatever appertains to them.

The sure one is the examination and comparison of existing instruments; the next is found in graphic representations, to be valued according to the realistic or conventional treatment the draughtsman may employ. The last and least satisfactory is that of written description, the difficulties of which are made more perplexing by the confusion attending names used by writers in different places and at different times. With the early keyboard we are only left with such indications as we can get from pictorial or written evidence, as no known keyboard is older than the end of the fifteenth century. At this point of our inquiry we ought not to overlook the keys of the hurdy-gurdy or vielle, the viol sounded by a wheel instead of a bow. The fact of this instrument having strings tuned as drones puts back its origin to when the drone was the only addition to melody.

The bagpipe was the wind instrument similarly burdened, and there is every reason to believe that the drone early became characteristic of the organ. It is a principle of great antiquity, perhaps prehistoric, still existing in the East, and particularly in India. The keys of the hurdy-gurdy are simply slides pushed back by the player, with projections to stop the strings and produce notes according to the vibrating length required; and as the instrument is held with the keys downward, these slides when released fall back by their own weight. It is possible that the hurdy-gurdy keys suggested the contrivance of balanced levers for stopping the monochord, and thus the clavichord, a complex of monochords, for at first the strings of it were of equal length, came about; but it is equally possible that the invention of balanced lever keys was earliest applied to the organ. We have to step with great care in this inquiry.

Of what happened, if anything, in the eleventh and twelfth centuries concerning keyboards, we know nothing. The first glimmering of light is in the thirteenth century. At that epoch a small portable organ for processional use, a shrill pitch giver and little more, had been invented. One of the valuable results of the music division of the inventions exhibition of 1885 was the publication of important books concerning music and musical instruments, two of which were undertaken by Mr. Quaritch. The one I now particularly refer to is entitled "Notes on Early Spanish Music," with illustrations of thirteenth and fourteen century instruments. The author is Don Juan Riaño, who was the special commissioner appointed for Spain, in connection with the music loan collection attached to that exhibition.

I had the great privilege to found that collection which was shown in the Royal Albert Hall, and was officially associated with it as chairman of the special loan committee. I may also mention that I was honored with a gold medal awarded by the executive council of the exhibition for these services. In Don Riano's book there is a drawing, copied from an authenticated manuscript of the thirteenth century, in which a portable organ, or *portatif*, appears. It has nine pipes, but it has been sufficient to the artist to figure three keys, which are hardly keys, in the sense of levers, but evidently represent those gimlet-looking finger stops of which I shall give other instances. When depressed by the fingers they lowered, by some internal contrivance, the valves or pallets necessary to admit wind to the pipes they served. There is no clew to the actual notes. The set of drawings this example is contained in belongs to the *codex* of the "Cantigas de Santa Maria," of which there are three manuscripts: one in the National Library, Madrid, and two in the library of the Escorial. The Spanish Royal Academy have just published this work; but these interesting and important musical miniatures had already appeared in "Instrumentaria Española," by Don Francisco Aznar, Madrid, 1880.

I will defer the next illustration from Don Riaño's book, in order to continue with these finger stops, which evidently remained in use in portable organs after balanced keys had been employed. An instance of them may be seen in our own National Gallery, in an altar piece by Orcagna, the date of which is given in the catalogue as A. D. 1357. The order of these stops is not clear, but seems to be chromatic, and the sharps are of the same color as the naturals, not contrasted as afterward became the custom. Another instance of such an instrument is found in a beautiful female figure, representing Music, depicted in a fresco, attributed to Taddeo Gaddi, and preserved in the Spanish chapel of Santa Maria Novella, Florence. She is represented as singing, while touching with her third finger one of these stops. There are two rows of stops, as in Orcagna's altar piece; and that the back and upper one is chromatic, I entertain no doubt. It is true that the back row appears to have as many stops as the front one, as may be seen in Mr. Timothy Cole's woodcut of the figure in the *Century Magazine*, March, 1889. This artist has since favored me with a photograph of the painting, to prove the accuracy of his engraving, so it may be assumed either that Taddeo Gaddi has not cared to be exact or that some of the finger stops were dummies.

Fifteenth century illustrations of similar stops may be seen in *portatifs*, depicted by Memling in paintings preserved in the hospital of St. John, at Bruges. The accuracy of these delineations is unquestionable, as is also the complete chromatic order of the stops. One of these representations of a *portatif* is in a painting in the famous shrine of St. Ursula; the other and larger in the "Marriage of St. Catherine." The latter is dated 1479, but the instruments represented may have been already old when the painter selected them for delineation. I now return to Don Riaño's next illustration of a *portatif*, which is different. It is copied from a fresco, an altar piece in the Cistercian Monastery of Nuestra Señora de Piedra, Aragon, and is dated 1390. Here is shown a *portatif* with three rows of pipes and balanced white natural keys, with one square chromatic key let in. Assuming that the treble of the instrument terminates at A, which occurs in fifteenth century positive organs, and recognizing the necessity in the plain song of a B flat for transposition, we cannot be wrong in regarding this square key as that note. If there is another B flat an octave lower, which according to Guido's scale was likely to be the case, the hand of the player covers it. Virdung, in 1511, figures a diatonic keyboard with two B flats, but this drawing is not altogether to be relied upon as an exact representation. There were such keyboards no doubt, only of an older fashion. Fra Angelico, who was painting in the first half of the fifteenth century, represents *portatifs* with diatonic keyboards, and, in one important instance, a dubious indication of incidental upper keys. I think, however, it is proved that full chromatic keyboards were in contemporary use with diatonic ones, including B flat, which was reckoned a diatonic note in the fourteenth and fifteenth centuries.

With regard to the keyboards of large church organs I cannot do better than briefly summarize the information on them, supplied by Prætorius in the second volume, "De Organographia," of his great work entitled "Syntagma Musicum," and published at Wolffenbuttel, A. D. 1618; it was completed by the Theatrum Instrumentorum seu Sciagraphia, that is to say, the illustrative plates, A. D. 1620.

I will pass by what he says about the earliest organs in churches, because he is not speaking from personal knowledge, to start with the famous Halberstadt organ, with which he was familiar. This organ was built, according to inscriptions upon it, in A. D. 1361, and renovated in A. D. 1495. Whatever happened in this renovation we shall find that the manual keyboards and compass of keys were undisturbed, and that probably the pedal keyboard was original, but as to this doubt may be allowed. The compass of the two highest keyboards was the same, and exactly that of the ancient Greek scale of fourteen natural notes, extending from B natural in the bass clef, "hypate hypaton," to A in the treble clef, "nete hyperbolæon." Thus proving that the church organ keyboard was a scholastic conception in the first instance, and we shall find it, although afterward only partially, for some time adhered to, and with Pythagorean, which was a nonharmonic tuning. The fifteenth natural key in that conception was the B flat near middle C, which belonged to the conjunct tetrachord, "trite synnemenon." But the necessities of the transposition of the plain song to accommodate voices, for which we have the authority of Arnold Schlick, who published his book in the same year as Virdung, A. D. 1511, had brought about the intercalation of the chromatic keys or "ficti" as they were then called—feigned notes—and consequently the restricted compass of the Halberstadt organ was, I have no doubt about it, originally chromatic. The lowest manual was a bass keyboard from an approximately 32 foot B natural to 16 foot C. The highest was for the mixture, various pipes of different but related pitches sounding together when a key was put down, without any attempt to sort them into various registers. In fact, the first essay in this direction is here seen, in the speaking pipes in the front of the organ, the "principal," as it was called, being on the second or intermediate keyboard apart from the mixture, and on the third or bass manual connected with the large deep bass pipes in the side towers. This principal was a four foot stop, the measure of an English principal of the present day, and it is curious that this old German tradition has really been maintained in England while it has not in Germany, where the eight foot foundation register is now the principal. We call the eight foot foundation stops diapasons—that is to say octaves below our principal, diapason being the Greek equivalent for octave. I can hardly accept the explanation which derives this name from an organ builder's rule, inasmuch as though called diapason his rule would serve to measure any pipe in any register. I believe the deep third keyboard pipes were originally used for drones, and to keep such notes continuously sounding was how pedals first came into use. We call a drone now a pedal point, and composers use it, especially for the tonic or dominant, with great effect. The Halberstadt pedals were for bass notes to the mixture, and were mixture

* Three lectures before the Society of Arts, London, 1891. From the Journal of the Society.

notes themselves, although without the highest rows of pipes. We may consider the pipes in the side towers were also upon the pedals, but as to this the text is not clear. If the usually received statement that pedals were invented by Bernhard, organist to the Doge of Venice, in A. D. 1470, then the Halberstadt pedals were no older than the renovation; but I think we may safely follow the suggestion of Prætorius that pedals had been long in use in Germany, and were only introduced by Bernhard at that date into Italy. They were not generally adopted in other parts of Italy, or in England either, until the present century. The compass of the Halberstadt pedals was only an octave: B natural, C, C sharp, D, D sharp, E, F, F sharp, G, G sharp, A, and B flat. We learn from Schlick that B flat had been the highest pedal key, and some inconvenience had been caused to organists by changing this note to B natural.

Now, the Halberstadt keys were very wide, on the two upper keyboards four inches from center to center of each key, with chromatic keys two inches wide, placed two and a half inches above the diatonic. The keys of the two discant manuals were rounded, but in the bass keyboard they were square. I am indebted to Dr. Hopkins for these measurements, which are given in his valuable article upon the organ in Sir George Grove's dictionary, and, I presume, are founded upon Prætorius' text and drawings. There could be, with this keyboard, no question of stretching an octave with the extended hand, or even more than a major third, and what we call fingering was entirely out of the question. The organist used the side of his clenched hand to depress the keys.

I will now briefly show, from Prætorius, the gradual upward extension of compass; but, for a long while, the B natural in the bass clef remained the starting note, according, as I have said, to the old Greek scale. It would appear that the pitch of the renovated Halberstadt organ was about a tone above our medium pitch of C, 528 double vibrations a second; but the pre-Reformation B natural was a fourth higher than this Halberstadt pitch, as was the case in the old Magdeburg organ, which was still remaining in Prætorius' time. We have seen that the Halberstadt organ had no higher key than the old Greek A in the treble clef. Prætorius describes the keyboard of the church organ of St. Egidius, at Brunswick, the date of which was A. D. 1456, as permitting the stretch of a fifth, instead of a major third, as at Halberstadt. He gives a drawing but, unfortunately, not the compass of the Brunswick keyboard; but he does of another organ of the same period, that of St. Salvator, at Vienna. In this the manual compass extended to C in the treble clef; the pedals as at Halberstadt. An undated organ at Minden, with keys 2⅛ inches wide, according to Prætorius' own measurement, had the same compass, pedal and manual as this Venetian organ. The next quoted by him was the organ of St. Sebald, at Nuremberg. Here the pedals went down to the lower A of the bass clef, the "Greek proslambanomenos," with B flat also added, but the manual kept to the normal B natural, ascending however to treble clef D. Another by the same builder, Heinrich Traxdorff, was in the Church of Our Lady at Nuremberg, without pedals, and only ascending in the manual to the Halberstadt A, but he introduced the octave register in the St. Sebald organ, and presumably in this, in addition to the already separated principal; the mixture remaining as the Hintersatz or Back organ. A further extension was made by Krebs & Mulner in the organ at Mildenberg, where the manual was advanced to the higher F of the treble clef; the lowest bass key still remaining B natural but the pedal starting from A, and from thence to the A above, a chromatic octave. We are now nearing the period of a great change in the organ keyboard, when Conrad Rotenburger built about A. D. 1475 the great organ at Bamberg, with similar compass; but to change it eighteen years later, that is in A. D. 1493, to the "long measure" in the bass, for the pedals, F, G, A, B flat, and then from B natural, chromatically, to the B flat above the bass clef, altogether an octave and a fourth; and for the manuals from the same F below the bass clef to A above the treble, three octaves and a third. The width of the keys was gradually being lessened until, when Cranz, in A. D. 1499, built the great organ of St. Blaise, at Brunswick, the octave was only the width of nine keys of Prætorius' time, when the octave had come to be comfortably grasped, as it has remained ever since, by an average hand. I ought here to state the compass of a modern German organ, and will take that of the great organ of Ulm, built by Walcker of Ludwigsburg, and accounted one of the finest German instruments. The manual keyboards, three in number, go from C below the bass clef to F above the treble, fifty-four notes, and the pedals from the octave lower C to D in the bass clef, 27 notes. Large organs built in this country exceed this compass. Messrs. Hill's Sydney organ has five octaves, from C to C, on all five manuals sixty-one notes, and pedals from C to F, thirty notes.

From the end of the fifteenth century the drone bass notes, as tonics or dominants to an octave system, appear to have got the better of the scholastic tetrachordal idea of the scale. Where the long measure, as it may be called, to the low F was not carried out on the keyboard, it was, in fact, as far as possible by substitution of pipes. The B natural key served no longer for that note, but for the G below it; the C sharp key doing duty for A; and the D sharp, when not retained for E flat, for B natural; but as this was hardly a drone note, E flat was often preferred. This was the short measure—for 300 years the well-known "short octave." In Italy the short octave has remained quite up to the present time, but generally with E for the apparently lowest key, which really sounds C, as F sharp sounds D and G sharp E; neither of these chromatics being good drone notes. Long drone pipes may be observed in pictures in which are represented the old portatifs, or processional organs, as in the Orcagna altar piece and the Spanish fourteenth century miniature I have mentioned. I can give many examples. And, in the Cecilia panel by the Van Eycks, painted for the Church of St. Bavon, Ghent, but now at Berlin, a positive or small chapel organ is painted in the most realistic manner, and the lowest note, D, has a special key situated below the keyboard at the left hand side, while above this key there is a latch, the only possible use for which could have been to fix a drone. Perhaps the deep drones came later into large church organs on account of the greater cost of the deep bass pipes.

It will now be interesting to trace the general history of the organ up to that epoch when it may be regarded as a complete instrument. We learn from Prætorius that the back organ, or huge mixture, as I have said, of many pipes to a key, was about the time of Luther's Reformation and translation of the Bible, dissected by the contrivance of separating rows of pipes of different degrees of pitch, as 16 ft., 8 ft., 6 ft., 4 ft., and so on, into registers by means of slides acted upon by drawstops. About this time, also, pipes, which had all previously been open from the mouth piece to the upper end, were supplemented by certain registers of covered or stopped pipes closed at the upper end, thereby introducing the contrast of a quieter and less penetrating tone quality. These stopped pipes were an octave lower in pitch than open pipes of the same length, from an acoustical reason that a node is formed at the closed end of the pipe and thus the wave length becomes equivalent to twice the wave length of an open pipe corresponding in length. An important structural change, such as the formation of independent registers, was soon taken advantage of for introducing contrasts of various tone qualities. Improved methods of wind supply, and, as has been explained, an extended manual compass with narrower keys admitting of an octave being grasped, an extended pedal compass and lastly the invention of reed stops, which Prætorius places about A. D. 1530, made the sixteenth century organ complete in all essentials; but to be improved upon, added to, and transformed until, in the present day, it has become a triumph of tone, color, and effective combination, and of mechanical skill, assisted by pneumatics and electricity.

The sketch of a complete organ is as follows: A wind supply, pumped by hand labor, hydraulic power, or gas, the air being compressed, as well as collected, from the bellows, is conveyed to the wind chests, where it remains until liberated for use by the player. The top of the wind chest, upon which the pipes stand, is called a sound board, but has nothing to do with resonance; and the pallets, or valves of the channels of air which lead to the pipes, are closed until acted upon by the key mechanism, which is under the control of the player. The action of a key with the old tracker movement is very simple. When the player puts one down, the other end of the balanced lever raises a sticker, which acts upon mechanism governing what is technically and expressively called a "pull down" attached to the pallet.

Formerly, the weight of a touch, and consequent amount of force required from the player, was in direct proportion to the increase of weight from the accumulation of tracker movements; but by contrivances to equalize wind pressure, and particularly by the pneumatic lever, the invention of the late Mr. Barker, who also invented an electric action, the touch of the organ may be as light, with any number of stops drawn, as that of a piano or harmonium. The pneumatic lever is a small power bellows attached to each key, and supplied with high pressure wind by the key being put down. The service of this invaluable lever is auxiliary to the finger in raising the action. The pipes are of metal or wood, those of metal being a mixture of tin and lead, and are either flue pipes with mouth pieces or reed pipes in which is inclosed a vibrating tongue of metal. Flue pipes may be, as already mentioned, open or stopped at the upper end. Their length and size varies with the pitch of the note; and their scale and form of air column varies according to the quality of tone required. The air, entering a metal flue pipe from a wind chest, is arrested by a flat piece of metal, called the "languid," and, being diverted by it in its direction, is forced through the mouth between an under and an upper lip, the latter being a fine beveled and indented edge, against which the wind thus directed breaks into a state wherein, according to Mr. Hermann Smith's theory, suction alternates with compression, and that portion which goes into the pipes sets up isochronous vibrations, that, agreeing with the period of vibration of the pipe, make the note, and last as long as the pallet remains open. In a wooden pipe the air is divided by a wooden block, performing the same office as the metal "languid." This is the same in principle as the flute player's *embouchure*. His breath passes from the throat, through the mouth and lips, against a sharp edge, giving access to the air contained in the flute. The effective length of an open pipe is measured from the languid to the upper end of the pipe, and in a stopped pipe from the block to the stopper and back again. In the reed pipe the foot is a metal case called a boot. In the boot is a round piece of metal also called a block, pierced in two places, the larger of which contains the reed, and the smaller the tuning wire which regulates the length of the tongue or reed so as to give the true note. The complete reed is a brass tube, in which there is a narrow opening, covered by a tongue of the same metal, the lower end of which is free to vibrate. Air when admitted to the tube forces the tongue away from the orifice, to which it returns by its own elasticity, and the puffs of air thus ejected establish the note, their rapidity determining its pitch. The length and shape of the tube affect the tone quality. As the tongue when at rest covers the opening, unlike that of the harmonium, which is free of such contact, it is known as a beating or striking reed. By the operation of slides which exclude or admit air to whole rows of pipes are formed the registers or varieties of pitch, power, and tone quality, governed by the draw stops. Each of these is really a separate instrument, but bands of them, so to speak, which have certain affinities, are grouped into departments, under control of separate keyboards, called the great, choir, swell, solo, and pedal organs. Not all necessarily in one instrument, especially the solo. Mechanical couplers and composition pedals, the latter the invention of the late Mr. Bishop, assist the player in his combinations. In adapting the pneumatic principle to these mechanical arrangements Mr. Henry Willis has done very much to facilitate performance upon large organs. The great organ has the typical pipes of the organ, the diapasons, and in England, before pedal organs were introduced, which was not, as already said, effectively done until the beginning of the present century, were upon a light wind and of a fine mellow quality. The different balance of power in the modern organ has unfortunately, yet unavoidably, done away with this musical excellence. As well as these foundation stops there are gathered upon the great organ all those stops, flue and reed, that are most brilliant, as well as the mixtures; and also the reed trumpets and clarion, of 16, 8, and 4 ft. stops, which have great richness and power.

The choir organ contains stops of lighter character, and carries with it the idea of accompaniment, as the name implies. The swell organ has grown into very great importance on account of the expression gained by its being in a box with Venetian shutters, which when closed materially reduce the tone, and as they open, produce an effective crescendo. The swell organ is entirely of English origin, and the expedient of louvres or Venetian shutters, in use for the last hundred years, is an adaptation of the harpsichord Venetian swell, invented in 1769 by Burkhard Tschudi, the founder of the house of Broadwood. It is now well known in France, and is there called Récit. It is less known in Germany.

The chief advocate for the extended introduction of the swell box in this country is Mr. G. A. Audsley, who has not only urged it on logical grounds in his treatise on "Concert, Church, and Chamber Organs," published in the columns of the *English Mechanic* (1886-8), and his recent lectures on the "Swell in the Organ," but has practically proved the great advantages to be secured by the multiplication of expressive departments in the organ. About twenty-five years ago he schemed and constructed his own chamber organ, which was, when finished, and still remains, for its size, the most flexible and expressive pipe organ existing. This can easily be understood when it is known that out of its nineteen speaking stops fifteen are rendered expressive by being inclosed in swell boxes. The two expressive divisions of the great organ, on the lower clavier, are inclosed in two independent swell boxes; the only stop here uninclosed being the *principale grande* (open diapason 8 ft.) The upper or choir manual being entirely expressive. The range of expressive effects and *nuances* secured by these means is remarkable, while the tone qualities of the stop remain unaffected. Mr. Audsley now advocates inclosing a portion of the pedal organ to make the bass also expressive. Among organ builders of the present time, Mr. Roosevelt, of New York, makes the greatest use of the swell box. For instance, in his organ recently erected in the auditorium at Chicago, he has, out of its eighty-six manual speaking stops, rendered seventy-nine expressive by inclosing them in five separate swell boxes.

The solo organ is quite modern. Its introduction is attributed to the late Cavaillé-Coll, in France, and Mr. Hill, in this country. The intention of the solo organ is to supply certain effective reed stops on exceptionally heavy wind. The pedal organ is the general bass to the whole instrument. In the largest instruments the 16 ft. diapason and other stops are doubled by 32 ft. open metal and reed stops, and Messrs. Hill & Son, in their great Sydney organ, have actually introduced a 64 ft. reed, the harmonics of which blend in the general effect. To complete the pedal organ, softer stops are now required, of which Mr. Casson is the earnest and able advocate. The charm of a soft bass, in these days of mechanical progress and corresponding stress of life, seems to be everywhere disregarded. I cannot but think that the mechanical progress so wonderfully shown in the modern organ has now gone beyond the intrinsic musical value of the instrument, and attention should be given rather to the improvement of voicing and combining allied registers in suitable families, with the general advancement and proportioning of tone quality, so as to secure a real economy of the various departments. With regard to the extraordinary inventions which have attached pneumatic and electric aid to the organ, something I think may still be said for the old tracker action, which does allow a player gifted with a fine sense of touch some personal control, through the pallet, over the tone denied to him when these natural forces intervene. I should say mechanical ingenuity is not exhausted for ameliorating any difficulties presented by the old movement. I admit that the influence of personal touch on the organ is a debatable question; but I am not alone in upholding its possibility, and the occasional revelation of such a power in the player. The incompleteness of this sketch of the organ would, I am afraid, appear impertinent if I could not refer those who desire more information to the admirable articles by Dr. Hopkins, in Sir George Grove's "Dictionary of Music and Musicians," by R. H. M. Bosanquet, in the "Encyclopædia Britannica," and one in Sir John Stainer's and Dr. Barrett's "Dictionary of Musical Terms."

In the seventeenth century, and perhaps the sixteenth, an interesting offshoot of the organ was the regal, a complete reed stop taken from it and used as a separate instrument for accompaniment in convents and elsewhere. These beating reed instruments are now very scarce. I believe I possess the only large regal in this country; it is an almost portable vox humana. The regal might have been regarded as the prototype of the harmonium, had there not been an unbridged gap between the discontinuance of the regal, which became entirely forgotten, and the invention of the harmonium and its congeners, which did not happen until the present century had come in. The principle of the harmonium is the free reed, the opposite to the beating reed of the organ, the regal, or clarionet. The tongue does not touch the frame surrounding it, and the action of the air in the harmonium is to force it away, and in a now favorite variety of that instrument, the American organ, by suction from, the opening, to which it returns by its own elasticity, thus setting up, by puffs of air, isochronous vibrations. The inventor of the principle of the harmonium was a Frenchman, Grenié, who, early in the century, contrived a free reed keyboard instrument, and called it *orgue expressif*. The invention was completed in 1840, by the late M. Debain, who introduced air channels, to control tone quality, and gave his instrument the name of harmonium. It had an air reservoir, to insure a uniform wind pressure. M. Alexandre, also of Paris, gave the player the discretion of doing without this reservoir, by letting the wind supply act, by means of an expression stop, directly upon the reeds, thereby giving the harmonium a power of expression it had not before. The harmoniums of Mustel, of Paris, are the most expensive and the most admired. The American organ, which acts by wind exhaustion, is said to have emanated from Alexandre's, but was first made popular in America. The tone is softer, and of less characteristic tone quality than that of the harmonium, and the expression stop is wanting.

Mr. Casson informs me that, by a pressure-regulating screw of his invention, he can give the harmonium and American organ an almost indefinite gradation of power, from *pianissimo* to *fortissimo*; and that the valve is so sensitive that a slight trembling of the finger on a key will produce a vibrato. If this is carried out, the harmonium will be much increased in importance as an artistic instrument. In another direction, that of purity of intonation, an harmonium has been invented by a Japanese amateur, Mr. Shohe Tanaka, called by him, from a suggestion of Dr. Hans von Bulow, "Enharmonium," which, by dividing the octave into twenty keys, increased by a simple mechanical contrivance giving enharmonic changes, governed by a knee lever to twenty-six notes, obtains with certain scarcely perceptible limitations absolute purity of intervals and chords; and by a transposing movement, effective throughout the range of the whole chromatic octave, all keys with their modulations are played in the C major or A minor position. The value of this instrument, the fingering of which, owing to the transposition, is not difficult, for choral accompaniment is evident. The instrument has really thirty-six distinct vibrations in each octave, of which only twenty-six are utilized in any one position of the transposed keyboard.

Before proceeding to the last instrument of which I have to treat, the pianoforte, it will be interesting to go back to its precursors, the clavichord, spinet, or virginal, and harpsichord. The use that has been made of all these instruments, and their common possession of strings, resonance boards, and keyboards, makes the clavier instruments a group apart, but of the highest importance to the historical development of music. The original member of this group was probably the clavichord, but it is an inference only, from the simplicity of its construction and the certainty that it was based upon the mediæval monochord. The invention is nowhere recorded. The earliest reference that has been met with to a clavier instrument has recently been discovered by Mr. Edmond Vander Straeten, a well known Belgian musical archæologist. It is to be found in the seventh volume of his great work, "La Musique aux Pays-Bas." It appears that, in A. D. 1387, King John, of Aragon, requested his brother-in-law, Philip the Hardy, to procure for him an instrument which he calls "exaquir;" and in repeating this request the following year, he describes it as "resembling an organ, but mounted with strings." He also asks for a player able to touch both organ and "exaquir." There has been a musical instrument mentioned in the fifteenth century French poetry long waiting for identification—the "echiquier." There can be but little doubt, according to Spanish and French phonology, of the identity of these names. Curiously enough there is a German form, "schachtbret," in some old rules of the Minnesingers, bearing date A. D. 1404. Whether this organ with strings was a virginal or clavichord we cannot say, but the name "echiquier"—"chequers"—may have come from an alternated color of the keys, or perhaps from a pattern upon the case of the instrument, as seen on some old portatifs. Both clavichord and spinet or virginal were known in the fifteenth century, and the latter had certainly, and the clavichord presumably, attained a useful degree of completeness. There is no clavichord so old known to exist, but an Italian trapeze spinet-shaped one was shown in the Paris exhibition of 1889, dated A.D 1547. This is the earliest I know of. The clavichord came from the monochord by adjusting a keyboard to a set of monochord strings, that is to say, strings of the same length and pitch, like an Æolian harp is made, and stopping them by little brass uprights, a little widened at the top where they came in contact with the strings, these stoppers—which not only excited the sound but acted as bridges—being called tangents. There was only one wooden bridge, that on the narrow sound board; a strip of cloth interwoven among the strings prevented any jarring on the further side of the tangents, and also damped the strings all along, when the tangents by the return of the keys quitted them. The strings were early attached in pairs, similar to the lute and other stringed instruments. By making the keys twisted, two, three, or even four tangents were made to act on one pair of strings. At the beginning of the eighteenth century the clavichord got its full number of strings, each pair having its own tangent, and this was the clavichord of Bach, a gentle instrument, which best renders the tender sentiment with which much of his keyboard music is charged.

The spinet was the application of the key-board to the mediæval psaltery, a form of dulcimer, but with plectra, not hammers. The oldest known spinet is dated A. D. 1490, and was shown in 1888 at the Bologna exhibition. Existing records show how much this instrument came into favor about that epoch. When, in 1509, the Chevalier Bayard, the famous knight without fear or reproach, was severely wounded at the siege of Brescia, he was carried to the house of a nobleman whose wife and daughter nursed him and entertained him during his convalescence by playing to him upon the lute and *espinette*, as the French call the spinet. The upright spinet was called "clavicytherium." I am of opinion that the beautiful upright spinet Mr. Donaldson owns, obtained from the Correr collection, and shown in the Loan Collection of 1885, although undated, may be as old as the 1490 spinet of Count Manzoni. There is an exact drawing of it by William Gibb, in my "Musical Instruments, Historic, Rare and Unique" (A. & C. Black, 1888). The spinet had one string only to each note, and the sound was excited by a little point of quill projecting at a right angle from a wooden upright placed upon the end of the key and called a jack. This also bore a cloth damper. According to Scaliger the quilled plectra were introduced in his boyhood. He was born A. D. 1484. Buff leather was introduced in later years, but never superseded the use of crow quills. Perhaps brass wire preceded the quill points, as Mr. Donaldson's upright spinet certainly had such plectra. After the sixteenth century the musical value of the spinet hardly increased, but it gained somewhat in power, and was a brilliant instrument compared with the clavichord. Extended lengthways into the grand piano shape, and with two, three, and sometimes four strings to a note, generally with one string an octave higher in pitch, more rarely one an octave lower or bourdon, the spinet thus multiplied early became the more powerful and important harpsichord. Double keyboards and stops for registers showed its affinity, at least in idea, to the organ. The harpsichord certainly existed in the sixteenth century; there is one in South Kensington Museum, dated A. D. 1521; it died out with the spinet and clavichord in the last quarter of the eighteenth, unable to maintain the struggle for existence against the piano. Perhaps the last harpsichord was one bearing Clementi's name, dated 1802, which was also shown at the Bologna exhibition. Beethoven's "Moonlight" sonata was published in 1802 for harpsichord or piano-forte, and there is a record that Himmel played upon a harpsichord in public, at Berlin, as late as 1805. All the keyboard stringed instruments, whatever the size and however the sound may be produced, have certain structural peculiarities in common, and especially the apparatus for resonance, the barred sound-board, of cypress in the old Italian spinets, of spruce in the modern piano; all come under the same acoustic generalization of resonance as Strad fiddles, Bologna lutes, or Andalusian guitars.

The piano-forte was invented by Cristofori, of Padua, in the first years of the eighteenth century, to satisfy the desire for a stringed clavier that should combine the expressiveness of the clavichord with the effectiveness of the harpsichord; it was, at first, a sufficiently facile instrument, and contained those principles of resonance—resistance to strain and suppleness of key action—that still characterize it. Cristofori solved three important problems, the first of which was to counteract the strain of the thicker strings necessary to withstand the impact of hammers. The second, allied to the first, was to compensate for the weakness caused by the opening between the turning-pin block—technically, "wrest-plank"—and the sound-board, imperative for the hammers to rise to the strings. The third was the mechanical control of the rebound of the hammer from the strings—technically, "escapement"—so that the hammer should not block against the strings and prevent vibration. All this he did, and more, for he invented the check, or movable rest for the hammer-tail, the simplest expedient to preserve the position of the hammer for a repeated blow—technically, "repetition." I am glad to be able to show models of Cristofori's actions, one made from the diagram in Scipione Maffei's account, published in the *Giornale dei Letterati*, A. D. 1709; the other, a remarkable piece of mechanism showing the check as well as the ingenious escapement, from grand pianos actually existing, dated 1720 and 1726. The much-talked-of pianos by Silbermann, acquired by Frederick the Great, and still at Potsdam, have Cristofori's action. Now if we raise the lid and look inside a modern grand piano, we shall see first the strings, three in number for each note, of cast steel wire—perhaps the strongest tensile material in the world—with the length and diameter increasing from the treble to the bass, and single bass strings for the lowest notes, overspun with fine copper or white metal wire to add to their weight, to make up for the strings in that part of the scale being theoretically too short. It may surprise some here to know that each of these three string notes, when up to the pitch of a London orchestra, has, in Broadwood's concert grand pianos, an average drawing power or tension of approximately 500 lb., so that the notes have a strain, and that always when at that pitch, of nearly twenty tons. This large aggregate is exceeded by some foreign makers. To withstand this enormous strain, the strings are held at one end by coils round the tuning pins, which are driven into a strong structure of beech and wainscot, called the wrest-plank; and at the other end are hitched upon smaller pins fixed into an iron or steel plate which is carried round the bent side to the end of the case. Their bearing points are upon the bridge attached to the sound-board, and the brass agraffes which collectively form the wrest-plank bridge. Bars of metal cross from the wrest-plank to the string-plate, and are so adjusted and fixed that the instrument proper is in an immovable iron frame. American and German makers have a single casting. Beneath the strings from where the hammers rise, to the bent side, back, and end of the case, is the sound-board of spruce fir, barred beneath with batons, usually of the same wood, technically "belly-bars," which strengthen the belly, and by increasing its elasticity, extend its power to form nodes or centers of vibration, and thus respond more promptly and effectively to the vibrations which are passed to it from the strings, when set in movement, through the hardwood belly bridge. A good sound-board reproduces all figures of vibration, however complex, exactly, and as freely as they are brought to the ear through atmospheric air, and re-enforces them so that the almost inaudible sound of the wires becomes the satisfactory fullness of tone we hear when a good piano is played. All pianos, upon whatever system they are made, have the features I have just described in common, also a wooden substructure of heavy beams, which keeps the case intact and rigid; but there are differences of application which are the choice of the makers, and are sometimes of their invention. In Broadwood's concert grand, one diagonal bar bears the greater part of the strain, its angle to the string plate being disposed with that object, while Steinway's, and nearly all foreign grand pianos, have more bars, and the bass strings crossing the long steel strings, with the wider scale and expanse of sound-board permitted by that disposition. For me, the tone of an overstrung bass is unduly powerful, and is open to the same objection I have touched upon in large organs, that soft, pure basses are not attainable. We have reached an aggregate of power in the grand piano which almost silences the stringed quartet, and even competes with the full orchestra. What we want is a pianoforte tone that gives us all the power and all the charm of varying *nuance* we can desire, with a tone-quality as specialized in character as the harpsichord tone was, that shall have the brightness and energy of vibration of the trumpet, without the blare.

I must pass by the advisability of iron frames in a single casting, for which the great convenience and popularity places my own want of faith at some disadvantage, to make some reference to the not less important question of the mechanism or action. The hammers attack the strings with an almost incredible variety of velocities, according to the player's scale of force. It is ider and more various in the English action, and is, therefore, more open to the characteristic individual feeling for tone; while Erard's action, which, in principle, is generally adopted abroad, is considered far more facile for the pianist's *technique*.

The domestic upright piano is now restricted to the various modifications invented with the instrument about 1800, by Isaac Hawkins, and improved some sixty years since by Robert Wornum, the general merits of which have caused it to be, in these latter days, employed in every piano-making country.

The structure of smaller pianos is, in principle, the same as the concert grand. I have, in this lecture, preferred to deal with the general principles of piano construction, rather than to touch upon the debatable points, which would take long to discuss, and could hardly be settled, inasmuch as piano making, like all other musical instrument making, is an art, and cannot be brought down to the level of mere mechanical manufacture. I think those who play the piano should have some acquaintance with those general principles, including that of sympathetic vibration, which the player controls with the pedals, a natural Æolian charm and prerogative of the instrument, divined by Beethoven, but the true use of which we owe to Chopin. I believe, if consideration were given to those principles more than it is, the unreasonable demands some players make upon this singularly responsive instrument might be reduced, and to the advantage of the cultivation of a feeling for tone which is incumbent on wind and other stringed instrument players, but is too frequently disregarded by those who play the piano.

I ought to refer the inquirer for further information about the construction of the piano to my paper upon it, read before the Society of Arts, March 7, 1883. It was published in the *Journal* of March 9 and (Appendix) September 21 of the same year. For this paper I received one of the Society's silver medals.

I have now an agreeable duty to perform in thanking Mr. Herbert Bowman for the loan of his beautiful clavichord; Messrs. John Broadwood & Sons, for the loan of the harpsichord, and spinet, and the wrest-plank, belly and model of action of a concert grand piano; Messrs. S. & P. Erard, for the loan of a model of their grand piano action; and Messrs. W. Hill & Son, for contributing a variety of interesting organ pipes, which show how different tone qualities are produced. Illustrations of the organ, harmonium, and piano are on this occasion scarcely necessary, but as few here can be familiar with either the clavichord or harpsichord—particularly the former—I will conclude by a performance on these instruments. I will play Bach's "Fantasia Cromatica" upon the clavichord. It was composed for this instrument, and may be said to rest upon the chromatic scale and its characteristic chords, the diminished seventh and ninth, resulting from equal temperament, and intolerable in the mean tone. As this instrument demands absolute quiet, I will first play a prelude by the same composer, so as to accommodate the ear to the very limited sound. For the harpsichord I will play the double keyboard variations from Bach's 30 variations in G—known as the "Goldberg." I believe I play them for the first time in London, as recently, at Oxford, I played them for the first time in England. As the two keyboards must be of equal power I shall use the eight-foot registers. The four-foot, or octave, must be reserved for the last variation, the "Quodlibet," a humorous combination of two airs played on one keyboard; and I will use the octave also in the repetition of the air, which, according to the composer's intention, concludes the work. A drawing, published in the "Zeitschrift fur Instrumentenbau," of a harpsichord which belonged to J. S. Bach, and was furnished with bourdon and octave registers, will be found among the pictorial illustrations I exhibit.

ASPHALTUM.

MR. E. W. PARKER, in a census bulletin relating to mineral industries, makes the following interesting statements respecting asphaltum. In his account he relates that gilsonite, elaterite, uintite, wurtziilte, albertite, grahamite, asphaltum, maltha, and brea are names given to various semi-solid bitumens which differ considerably from one another in their chemical composition, in their action with acids or other agents, and upon the application of heat; but asphaltum is the common term applied to the class when used industrially, the varieties being designated by the producing locality. They are, moreover, used in the main for the same purposes.

Elaterite, albertite, and grahamite are very nearly alike in composition and physical properties. The first occurs principally in Derbyshire, England, and was so named by Hausmann, on account of a certain elastic tendency and its resemblance to India rubber. Albertite, a very similar mineral, occurs in Nova Scotia. Grahamite was found in West Virginia, but the deposit was small and has been exhausted.

Gilsonite and uintite (or uintahite) are names given to the asphaltum of Utah, which is the purest that has yet been found, the crude mineral containing about 90 per cent. of bitumen. It was discovered by Mr. S. H. Gilson, of Salt Lake City, by whose name the mineral is generally known in commerce, and by the Gilson Asphaltum Company, of St. Louis, engaged in its mining, although mineralogists prefer to treat it under the name uintite, given it by Prof. W. P. Blake in the first article published on the subject, from the producing locality, near the Uintah mountains. The gilsonite deposits in Utah lie in the northeastern part of the territory, near Fort Duchesne, and just east of the Uintah reservation. Other fine deposits exist in the Uncompahgre Ute reservation, a short distance from the Colorado State line. During the last session of Congress an unsuccessful effort was made to open to settlement the land on which these deposits lie, which is that known as the "Twelve mile strip," embracing two rows of townships on the bank of White River. The mineral is found in veins having nearly a perpendicular dip, and are said to be of good thickness and in a position to be easily mined.

Near the locality from which gilsonite is obtained is a deposit of another peculiar form of bitumen, to which Prof. Blake has given the name of wurtziiite. This mineral occurs in Wasatch County, Utah, between Salt Lake City and the Green River Valley. When first discovered it was thought that a mineral form of caoutchouc had been found, but this assumption was soon disproved by tests showing that it had no tensile

elasticity and would not yield to the usual dissolving agents. It was then classed as a species of elaterite, but Dr. Henry Wurtz, after a thorough investigation, has shown it to be an entirely different mineral. No wurtzilite was mined commercially during the calendar year 1889.

Although for a number of years asphaltum in different forms has been known to exist in California in large quantities, it was not until 1888 that its production assumed any important proportions as an industry. In 1888 a large deposit of bituminous rock containing an unusually large percentage of asphaltum was discovered in Ventura county, and a company of San Francisco capitalists was organized for the purpose of developing and operating it. The owners styled this mineral "asphaltum," but as it contains but 24 per cent. of bitumen, the other constituents being silica (about 64 per cent.), oxide of iron and calcium carbonate, it should be classed among the bituminous rock products.

There are several deposits of bituminous rock in San Luis Obispo and Santa Cruz counties, in which the peculiar features of asphaltum formations are strikingly illustrated, clearly showing that they belong to no particular era or age; that they are found at various altitudes, and with no uniform character in appearance, hardness or chemical composition. Deposits of solid asphaltum and springs of viscid, oily material, commonly called "brea," occur in places not 1,000 ft. apart, and yet in strata of unquestionably different periods of formation. A number of companies are now engaged in its production.

Until the remarkable impetus given to the asphaltum industry in California and Utah in 1888, the island of Trinidad and the deposit of Seyssel, in France, and Val de Travers, in Switzerland, furnished the bulk of the world's supply. Cuba produces asphaltum of excellent quality, some of which has been imported into the United States. Venezuela has furnished a small portion of the supply in the past, and a few tons of bituminous limestone are imported annually from Germany and the island of Sicily. In the State of Tabasco, Mexico, large deposits of asphaltum are reported, but although at a convenient place for shipment over the Mexican National Railway, only a few small lots have been shipped.

The methods of preparing the various asphaltums for street pavement are in a manner similar, yet sufficiently distinct, to justify a brief description of each process. The bituminous limestone of France and Switzerland is prepared by being first ground to a fine powder, then passed through iron cylinders, into which air heated to a temperature of 500° F. is introduced. It is thoroughly stirred as it passes through the cylinders, and when it reaches the opposite end is removed in a plastic condition and spread upon a concrete foundation, compacted by hammers, and when cool the street is ready for use.

The Trinidad asphaltum, upon being unloaded at its point of destination, is placed in large tanks and heated over a slow fire for a few days, care being taken not to heat the mass sufficiently to cause distillation. By this process all foreign substances are eliminated; vegetable impurities rise to the top and are skimmed off, while the earthy constituents settle to the bottom, and the asphaltum is then in a condition for manufacture. For street paving the refined asphaltum is treated with the residuum of petroleum and mixed with fine, sharp sand in the proportion of 14 per cent. by weight or twenty-five per cent. in bulk of asphaltum. The mixing is thorough, and is made at a temperature of about 300° F. While still hot and plastic it is spread upon the foundation already prepared and rolled by heavy steam rollers. The advantage claimed for the Trinidad asphaltum over the French and Swiss limestone material lies chiefly in the granular nature of the sand used in preparing it, which prevents the slipping of horses.

Gilsonite is prepared for this purpose by being first pulverized and mixed with petroleum oil. The mixture is then heated, care being taken to keep the temperature below 500° F., as above that temperature gilsonite will decompose. This composite is mixed while heated with broken stone or gravel, and is then ready for the street. It has been ascertained that a mixture of about 80 per cent. gravel makes the most durable pavement.

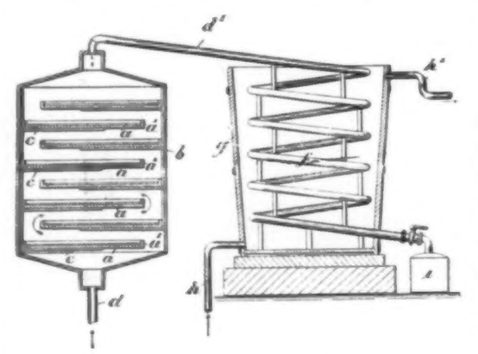
For the manufacture of street paving from the bituminous rock of Ventura and Santa Barbara counties, California, it is only necessary to mix it when heated with the sand of the locality where it is used. Sand is mixed with the asphaltum in the proportion of from three to eight times by bulk of sand to one of asphaltum. This method effects a considerable saving in transportation expenses. There is no appreciable loss of time in placing it on the street, as it requires only an hour after laying it to "set" and be ready for traffic. Once properly mixed and laid, it seems practically indestructible, as shown, it is said, by a section of this pavement which has been in use for eighteen months on one of the streets in San Francisco.

The bituminous rock of Luis Obispo and Santa Cruz counties is a sandstone thoroughly impregnated with bitumen. It is used almost entirely for street paving, and for that purpose is probably more easily and cheaply prepared than any of the asphaltum products. The only treatment necessary is to steam it, so as to thoroughly mix its ingredients and soften it for spreading to a uniform thickness and a smooth, even surface. Bituminous rock has supplied a limited local demand for ten or fifteen years, but it is only during the past two years that it has assumed any commercial importance as an industry. It is reported that pavements made of this material fifteen years ago, and used under heavy travel, have recently been removed and found to have lost very little either in weight or thickness; also that it stands equally well the high temperatures of the interior cities and the cold damp atmosphere of the coast. It is estimated that there are now 50 miles of bituminous rock street pavement in the State of California.

Although the greatest use for asphaltum is in the manufacture of street paving, it is by no means confined to that field. Large quantities are consumed in making floors for warehouses, cellars, wineries, etc. It renders the floors water tight, and is not affected by acids or gases. For lining dams, levees, and reservoirs a thin coat of asphaltum, put on in a melted state, presents a water tight surface, preventing loss by seepage. As a coating for piling, wharf timbers, ground ends of telegraph poles, etc., it gives almost absolute protection against not only the action of air and water, but also the destructive work of insects and barnacles. It is used as a cement for sea walls and other marine architecture, where its water proof character makes it especially valuable as a binding material. It is claimed to make wood conduits almost if not quite as durable as iron, and any iron or other metal work, such as anchors, etc., coated with it will not rust or be affected by sea water. It is also used as a roofing material, and, being practically a non-conductor of electricity, serves a useful purpose as an insulator for electrical wires. Varnish is manufactured from refined asphaltum or gilsonite by simply heating with spirits of turpentine.

A SUBSTITUTE FOR GLASS.

THIS is the invention of Friedrich Eckstein, of Vienna, Austria. In the production of the new substitute for glass he says: I dissolve from four to eight parts of collodion wool in about one hundred parts, by weight, of ether or alcohol or acetic ether, and with this I intimately combine from two to four per centum of castor oil or other non-resinous oil and four to ten per centum of resin or Canada balsam or other balsam (soft resin). The compound when poured upon a glass plate and subjected to the drying action of a current of air of about 50° Centigrade solidifies in a comparatively short time into a transparent glass-like sheet or plate, the thickness of which may be regulated as required. The sheet or plate so obtained has substantially the same



properties as glass, as it will resist the action of salts and alkalies and of dilute acids, and like glass is transparent and has no smell. On the other hand it has the advantage of being pliable or flexible and infrangible to a great degree, while its inflammability is much less than that of the collodion substitutes.

In the drawing, *b* indicates a vessel adapted to be hermetically closed and having the air inlet pipe, *d*, at bottom, the outlet pipe, *d'*, at top connected with or forming part of a condenser worm, *f*, contained in a refrigerator, *g*, of which *h'* is the inlet pipe for the refrigerant liquid and *h* the exhaust pipe. As shown, the condenser worm has a valved discharge, with which the receiver, *i*, for the condensed solvent is connected.

In the vessel, *b*, are arranged shelves that extend alternately from one wall of the vessel toward the opposite wall for the reception of the glass moulds, *a*, that have an edge flange, *a'*, that determines the thickness of the plates or sheets to be cast. These moulds, *a*, when placed upon the shelves, *c*, extend from wall to wall of the vessel, *b*, in one direction and project beyond their shelves in an opposite direction from one wall of the vessel, *b*, to near the opposite wall thereof, so as to form a zigzag passage for the heated air entering at *d*, thence passing under the lower mould around the right hand end thereof under the next succeeding mould and around the left hand end of the latter, under the mould next above the same, and so on alternately from right to left and left to right, the solvent being evaporated and condensed as it passes through the condenser.

The compound, after exposure to an air current of a temperature of about 50° Centigrade, as above stated, for some time, first becomes opalescent, then hardens and becomes horny and perfectly transparent, after which the moulds are taken out of the drier and the sheets or plates removed, when they are ready for use.

The compound, as will be readily comprehended, is of such a nature that any desired color or shade of color may be imparted to it by the admixture of the necessary pigment. The pigments should be soluble in the solvent used in the preparation of the compound if incorporated therewith; but the color may be imparted to the substance by surface application, aniline dyes or colors being employed, so that the sheets or plates may be used in lieu of stained glass. The material may also be ornamented by printing any desired design thereon.

If magnesium chloride or grape sugar is combined with the material, the inflammability thereof is very materially reduced, while an addition of zinc white or heavy spar imparts to it the appearance of ivory, so as to adapt it for use in the manufacture of collars, cuffs, shirt fronts, and the like.

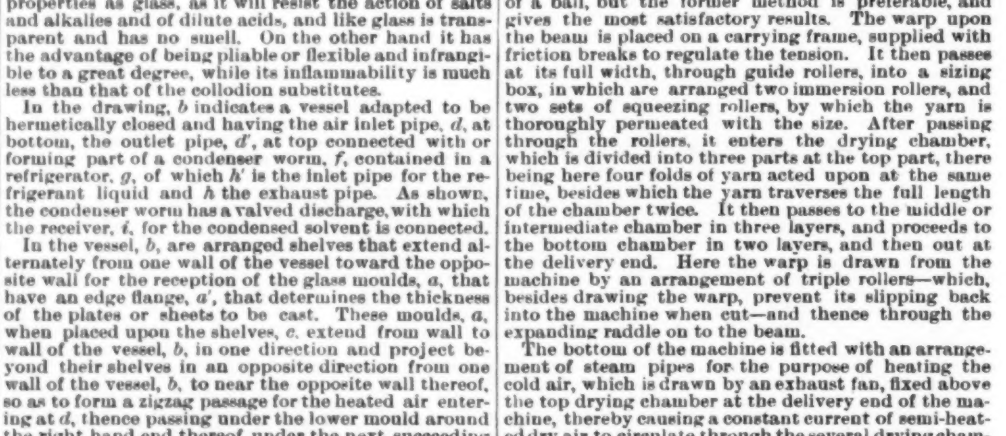
By suitably increasing the relative proportions of castor oil and resin a material having substantially the toughness and pliability or flexibility of leather is obtained, and such material may be fashioned into driving and other belting. The composition of matter is, however, adapted for use in many other ways—as, for instance, for table and other ware, in lieu of glass, as a substitute for celluloid, for emulsion plates, for surgical and measuring instruments, and for many other purposes.

WARP SIZING, DRYING, AND BEAMING MACHINE.

MESSRS. WHITLEY & SONS, Prospect Ironworks, Lockwood, Huddersfield, the well-known makers of woolen, worsted, and finishing machinery, are the producers of an apparatus for sizing, drying, and beaming woolen warps. In the whole range of machinery used in the manufacture of textile fabrics there is no single appliance of more importance than a reliable and trustworthy mechanism for the purpose named, and there is none more deserving of special mention than that made by Messrs. Whiteley & Sons, the chief feature of which is the sizing and drying of the warp, at its full width, at a fairly low temperature, the result being that every portion of the fiber emerges from the machine sized and dried with the utmost regularity. The importance of this will be fully appreciated in the after processes of production, as whatever insures an evenness in, and equal tension of, the warp must, naturally, greatly facilitate the weaving of the cloth, and, therefore, a better fabric is obtained. The machine is not in its experimental stage, but has been sufficiently long on the market, and has been used by so many of the best known firms in the textile districts with satisfactory results, that we may fairly describe it as a thoroughly reliable and successful mechanism. A few words on the manner in which the machine operates will be of service to those contemplating the purchase of an appliance for sizing, warping, and beaming woolen warps.

First, we would draw attention to the illustration, by the aid of which the mechanism will be easily understood. The warp may be brought to the machine on a beam, as it leaves the warping mill, or in the form of a ball, but the former method is preferable, and gives the most satisfactory results. The warp upon the beam is placed on a carrying frame, supplied with friction breaks to regulate the tension. It then passes at its full width, through guide rollers, into a sizing box, in which are arranged two immersion rollers, and two sets of squeezing rollers, by which the yarn is thoroughly permeated with the size. After passing through the rollers, it enters the drying chamber, which is divided into three parts at the top part, there being here four folds of yarn acted upon at the same time, besides which the yarn traverses the full length of the chamber twice. It then passes to the middle or intermediate chamber in three layers, and proceeds to the bottom chamber in two layers, and then out at the delivery end. Here the warp is drawn from the machine by an arrangement of triple rollers—which, besides drawing the warp, prevent its slipping back into the machine when cut—and thence through the expanding raddle on to the beam.

The bottom of the machine is fitted with an arrangement of steam pipes for the purpose of heating the cold air, which is drawn by an exhaust fan, fixed above the top drying chamber at the delivery end of the machine, thereby causing a constant current of semi-heated dry air to circulate through the several drying chambers of the machine, which, therefore, remains in continual contact with the warp. The dry warp on leaving the triple rollers and passing to the beaming frame is subject to the current of cold air, on its way to the bottom chamber of the machine, before it passes over the steam pipes. The guide rollers used in the machine also act as expanding rollers. Thus the yarn is kept opened out to its full width, and the air and steam, therefore, exercise their full effect upon it. The sides of the machine being of glass, the attendant can see the warp from its entry to its return from the machine. Facilities are afforded for the piecing of broken warp threads, through the application of a stop motion to the apparatus, so that no ends can remain long enough in the box to cause any irregularity in the quantity of size taken up. There is also an arrangement of lifting rollers and weights, by the aid of which the attendant can remove the warp from the size during the time the machine is not in operation, and replace it at will.—*Jour. of Fabrics.*



IMPROVED WARP SIZING, DRYING, AND BEAMING MACHINE.

SMITH'S IMPROVED MOULDING MACHINE.

THE engravings below represent in Figs. 1 and 2 a sectional elevation and a general view of an improved appliance for moulding in loam or sand, by the aid of striking boards, cylindrical, elliptical, or irregular forms, from 18 in. to 20 ft. diameter. The apparatus will no doubt be found very useful for moulding fly wheels, drums, and rope pulleys, in two or more parts. The method on which the appliance works is very simple. A particular shaped cam, in the case of an irregular shaped casting, is fixed inside the box as shown. A pin with a revolving runner is secured to the arm or strickle, and as the latter revolves the pin is caused to follow the shape of a cam, so as to produce the desired form of mould. If a circular object is being moulded in two parts, it is made with flattened sides, to allow, when put together, for the removal of the thin dividing cores shown in the general view. It will be understood from the above that various shaped castings can be made by this apparatus by altering the shape of the cam, and the joints can be prepared for machining, chipping, cementing, or calking by making the dividing cores suitable for the particular purpose. The makers of the apparatus are Messrs. Bentley & Jackson, of Bury, Lancashire.—*Industries.*

ELECTRICAL HORSE POWER.

THE horse power of a dynamo is expressed by what used be known as volt-amperes, divided by the constant 746, that is to say, the energy represented by a volt multiplied by an ampere is one 746th of a horse power. This constant is got from the fact that experiments on the decomposition of water, etc., have proved that the horse power expended in sending a current through any resistance is one 746th part of the current

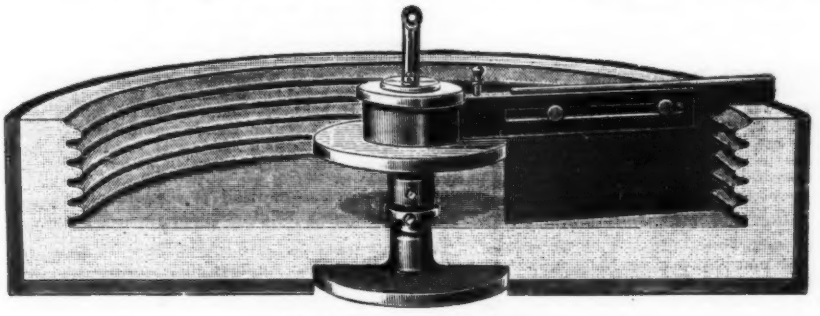


FIG. 1.—SECTIONAL ELEVATION.

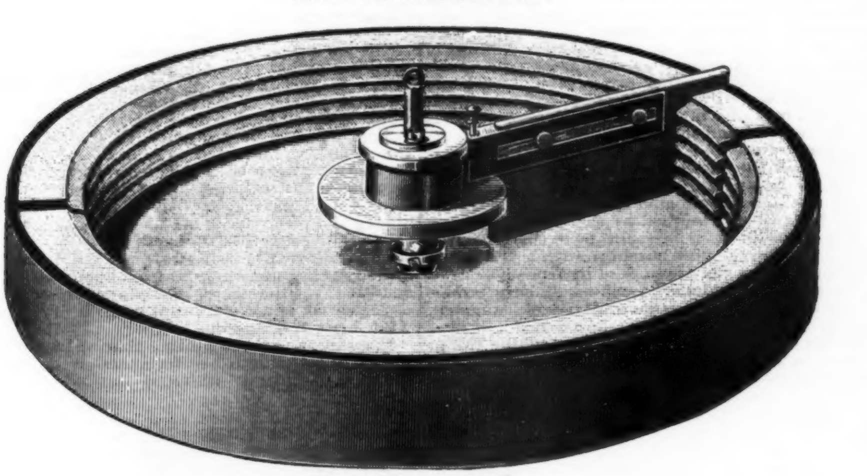


FIG. 2.—GENERAL VIEW.

IMPROVED MOULDING MACHINE.

in amperes multiplied by the electromotive force in volts impelling that current. To find the horse power of a dynamo it is only necessary to multiply the number of amperes by the volts and divide by 746. Thus a given dynamo produces, say, 200 amperes at a pressure of 350 volts, then $\frac{200 \times 350}{746} = 93{\cdot}8$ horse power. It matters not at all what ratio exists between the volts and the amperes. We may augment one and increase the other as we please.

Thus, for example, we might have a single ampere and 70,000 volts, or 70,000 amperes and one volt. The expenditure of energy would still be the same, viz., 93·8 horse power. When an engineer sells an engine to drive a dynamo, he can always ascertain the power exerted by his engine by means of the indicator. The electrician can always supply the figures relating to quantity and pressure, namely, the number of volts and amperes, and thus all the data needed are available for calculating the combined efficiency of the engine and dynamo, and the respective efficiency of each, provided that a trustworthy friction diagram of the engine can be had. The facts are so well known that we should not give them here were it not that it is desirable to state them in order that what follows may be readily understood by engineers who have only a general knowledge of electrical laws and phenomena.

The rules we have given for calculating electrical horse power are only applicable to continuous current machines. That is to say, dynamos which discharge practically continuous currents of electricity in one direction. In the alternating dynamo the currents flow alternately in opposite directions; the number of alternations being exceedingly rapid, as much, for example, as 1,000 in a second. It was at first believed that it would be possible to calculate horse power, in the case of alternating machines, just as easily as if the currents were continuous. Practice has, however, shown that this view is quite untenable; and the facts have furnished matter for much speculation among electricians.

Briefly stated they are as follows: An alternating dynamo sends a high pressure current, say 6,000 volts, through a cable and transformers. The transformers, however, do no work, no lights being on their circuit. The amperes are, say, 9. Then $\frac{9 \times 6{,}000}{746} = 72$ horse power, and the engine ought to indicate about 90 horse power. But strangely enough it will do nothing of the kind. It will indicate instead only about 17 horse power, or less. In a word, although there are apparently 72 electrical horse power being generated, the engine will only give a friction diagram. If now lamps are put on by degrees, there will be no difference in the volts and amperes, but the horse power of the engine will augment until at last a point is reached when the hand of the ampere meter begins to move. The addition of a single ampere will then suffice to render the expenditure of 100 indicated horse power necessary. Thus, then, it will be seen that the apparent efficiency of an electric lighting plant might be enormous, as much as three or four hundred per cent., while in reality it was very moderate. It is well that this truth should be carefully borne in mind whenever any statement of the efficiency of a given dynamo is put forward. But after every allowance has been made in this way, it still remains to be settled what the horse power of the dynamo actually is. Thus in the case we have mentioned, the machine requires no power to drive it up to 9 amperes output save that needed to overcome its friction, but at 10 amperes we find the engine indicating, say, 100 horse power. What, under the circumstances, is the real output in energy of the dynamo? So far as is known at present there is no means in existence for ascertaining the facts directly. They can only be got indirectly from the work done by the transformers.

Our engineer readers may not unnaturally ask us to explain the cause of the phenomena in question. We regret that we are quite unable to do this. Four or five theories have been advanced by as many electricians of eminence, but they are as yet unable to agree. The facts are very curious and complicated, and any statement of the theories advanced would be unintelligible to non-electricians. It must suffice to say that a great deal depends on the cable. Every conductor requires a certain quantity of electricity to charge it, just as, for example, a gas main must be filled with gas before it can begin to supply lamps. According to one view, a cable working on a continuous current is charged, to begin with, by the first revolutions of the dynamo. A cable on an alternating current is, on the contrary, charged and discharged at every alternation; and this charging, although registered by the volt and ampere meter, does not represent any great expenditure of energy.

The dynamo is, in a sense, working under the same conditions as a pump on a closed circuit. A pressure gauge on a main might show 200 lb. pressure within it while a meter showed a discharge of 1,000 gallons a minute, and yet the work done might be very small. This is a very crude illustration of what is supposed to take place, but it will serve to consolidate ideas, and we cannot hope to do more. The size of the cable, its length, the number of cables, and very many other details of construction, modify the results. It is more than probable, however, that before long a theory which will cover and explain all that is now puzzling will be propounded. Until this desirable end has been reached, it seems to be practically impossible to say what the true efficiency of an alternating plant may be, and how it compares with that of a continuous current plant, and it is more than probable that some new system of constructing ampere meters must be devised.

As matters stand, an engineer in charge of an electric lighting station may be misled concerning the work which his engine is doing. It is probable that in large installations, where there is an abundance of electrical talent available, no trouble is likely to arise in this way; but it is quite possible, on the other hand, that mistakes may be made when the plant is of comparatively small dimensions, and intending purchasers of alternating machines will do well, with the facts we have stated before them, to receive with caution all statements of exceptionally high efficiencies obtained when there are long lengths of cable in circuit. Finally, we would add that what we have written is not intended to be of any service to electricians, who are, or ought to be, to a large extent aware of the facts, but, as we have already stated, for the information of engineers possessing no acquaintance with the more recondite aspects of electrical phenomena.—*The Engineer.*

ON THE COAST OF LABRADOR.

PROF. ALBERT S. BICKMORE, of the American Museum of Natural History, New York, has lately returned from Labrador. With him, says the New York *Times*, came many photographs of icebergs, Esquimaus, and other natural and human products of that almost unknown northern country, together with a great quantity of notes and other material for the lecture on "Food Fishes from the Sea," which is to be the concluding one of the professor's fall course of lectures to teachers.

The journey was made for the purpose of learning as much as possible in relation to the Esquimaus, the codfish, and the icebergs. The latter were observed in their native lair, and, from the description of them given to a *Times* reporter by the distinguished traveler, a sight of some of them was alone worth the trouble and expense of the voyage.

Accompanying Prof. Bickmore on the trip were ex-President Robert Harris, of the Northern Pacific Railroad, and Beverly Robinson, a student friend. Mr. Harris went as far as Newfoundland and Mr. Robinson completed the journey to Labrador, and stopped in Newfoundland on the way back to shoot caribou in the western part of the country. He will have natives for guides, a good gun, and an abundance of ammunition, and may be expected to bring several caribou skins home to New York with him.

"We left New York," said Prof. Bickmore, "on July 11, on the steamer Portia, of the Red Cross Line. We reached St. John's, N. F., on July 16, having touched at Halifax. I bore letters from the British consul general at New York to Gov. O'Brien, of Newfoundland, and the latter offered me every facility and courtesy. On July 21, we left St. John's for the south coast of Labrador on the steamer Conscript. These steamers go out from St. John's every two weeks to visit what are known as the 'outports,' one going to the south and west shores of the island and the other to the east and north shores. The steamer in which I took passage was bound for the Strait of Belle Isle.

"Newfoundland has been called the Land of Mists. I have been absent from New York seven weeks, and the only delay by fog experienced was one of eight hours off the coast of our own Massachusetts near Martha's Vineyard. The cold water from the arctic regions mingles with the warmer waters of the Gulf Stream on the Grand Banks, thus turning that into a great fog-producing area. The winds from the south and east waft the fog against the coast of the continent from Nantucket to Cape Race. After passing that point we found clear skies, and during our voyage thereafter to the far north we had almost uniformly clear skies. The features and geological structures of the coast were therefore revealed as we steamed along, touching at every fishing village and hamlet, and never out of sight of land. For seven days on the route to Battle Harbor, we came to a new port every three or four hours.

"To one leaving the coast of the United States, the first feature of the coast to impress itself on the attention is its abrupt character. On the east side of Newfoundland the rocks have been and are exposed to the ocean swell, which ceaselessly thunders away at the great battlements of stone, excavating deep caverns wherever the structure of the stone is less dense. This action of the sea produces a series of arches and deep open cañons that give a precipitous character to the coast. The rocks, which are mostly of the Laurentian period, have been broken open and filled with fluid volcanic rock of later date. These volcanic rocks have usually been more pliable than the surrounding stone, and the sea excavated in them, with the result of giving them the peculiar character I have described.

"This peculiarity of the trap dikes was especially exemplified in one circular group of islands known as the White Bears. The islands were at one time rent asunder in radiating lines, like the divisions of an orange, and the spaces filled in with fluid rock which the sea afterward removed, leaving a series of deep chasms, all converging toward the center of the group.

"The principal object of my journey was to study the codfish and fisheries and the experiments now being conducted under the auspices of the Newfoundland government to restore the codfish to their original abundance. In the early days in the history of this, the oldest of her Majesty's colonies, all of the deep bays of Newfoundland were filled with codfish, but fish in the bays gradually diminished in numbers, until the fishermen were compelled to go further and further north during the catching season. The question then arose as to whether it was possible to re-establish the former abundance, or at least greatly increase the present supply.

"This was a great question, not only for Newfoundland, but for the human race, so many of which depend on the cod for subsistence. Three years ago the colony of Newfoundland secured the services of Mr. Nilsen, an expert pisciculturist from Norway, and a codfish hatchery has been established at Dildo Island, on Trinity Bay. The experiments are successful, and give promise of greatly increasing the supply of codfish.

"I was surprised to observe the remarkable purity of the sea water in that northern region. It is so clear that a silver dollar can be seen many fathoms down,

The water is salter, also, than the water of the middle Atlantic. The purity of the sea water extends to the very heads of the bays, and reminds one of the clear water at the coral islands. This pure condition of the water is more favorable to the success of Nilsen's experiments than the condition of the water at Wood's Holl, Mass., where experiments in codfish propagation are being conducted by the United States Fish Commission. At Nilsen's hatchery I saw codfish in every state of development.

"The question of the success or failure of the codfish hatcheries will depend largely on whether the cod hatched and propagated and put in the water will return to the bays in which they were originally placed or to any part of the neighboring shore. So far as the facts are yet ascertained, the codfish is more local in its habits than at first imagined. It appears probable that the cod come out of the deep sea into the bays in succession as the season advances. It was once thought the schools of codfish went up the coast, but it is now known they do not, but come directly from that part of the deep sea opposite, as may be said, to the bays. There is thus a separate school for each bay, and that this is so is proved by the fact that fishermen are able to find differences between the schools in different bays.

"The great importance of the codfish supply cannot be overlooked. Although it might at first sight seem impossible that man could take an appreciable quantity of fish from the sea, yet the fact remains that the codfish are far less numerous in their former haunts.

"At Dildo Nilsen has also propagated lobsters, and while I was there an agent of the commission reported that immense quantities of lobsters were beginning to be found where the young lobsters had been placed. This would seem to establish the local habits of the lobster.

"The codfish first come into the bays in the early spring to deposit eggs and obtain food. They appear in the greatest numbers when the caplin, a small fish, come to the shore in unnumbered millions, in such a multitude as almost to fill the water. Later on, when the caplin disappear, the squid come and furnish food for the cod, and finally, in autumn, there arrive in the bays great schools of herring, which are likewise food for the cod as well as lucrative prey for the fishermen. The abundance of these three food fishes is as great as ever.

"Reaching the Strait of Belle Isle, we passed along the north shore of Newfoundland to where it opens into the Gulf of St. Lawrence. Then we crossed to the south shore of Labrador. The whole character of the entire coast of Labrador cannot be better described than by the old navigator who called it the 'abomination of desolation.' The coast is absolutely barren. Further inland there are spruce trees of considerable size on the watercourses. In the far interior is the red Indian, who lives by hunting fur.

"The fishermen live, during the season, in hamlets on the Labrador coast. There is a 'stage' or crude wharf at each hamlet, covered with a shed. Here the fish are landed, cut, split, and salted. They are next transferred to wooden shelves on the rocks. A fishing shore belongs to whomsoever pre-empts it. There is no legal title. A man first goes to a part of the shore which is unoccupied and locates there. By common consent he can hold that shore as long as he returns and fishes from it. One fisherman told me he had fished at the same place for forty years. When the season begins, the fishermen transport to this desolate coast their families and some fowls and pigs.

"At Battle Harbor, which was reached on July 28, we changed to another mail steamer and continued our journey. This little steamer is subsidized by the Newfoundland government, and goes from hamlet to hamlet with mails and a doctor. The latter cures felons, cuts, and the ailments that affect the little isolated colonies. When I reached the coast I found the fishermen had been suffering from an epidemic of the grip. We stopped at fifty hamlets during our progress along the coast, reaching Nain, the northern end of our route, on August 2. The distance from Battle Run to Nain and return was 1,010 miles.

"Next to the codfish I was interested in the icebergs. The Arctic Ocean is an inclosed gulf, like the Gulf of Mexico. The warm waters pour into this frozen bay in along the shores of Iceland and Norway, keeping those coasts so completely clear of ice that on a voyage once taken to North Cape I did not see a single particle of ice, although North Cape is much further north than the north shore of Iceland. The current of warm air encircles the Arctic basin and comes out along the east and west shores of Greenland, bringing with it the fragments of land ice carried out by the glaciers. The icebergs are composed of fresh water ice as fresh as that of Alpine glaciers. They come out of the high land of Greenland, and are carried south by the Labrador current, crossing the track of the transatlantic steamships, and gradually breaking up and disappearing in our latitude of the ocean.

"When the bergs are detached from the land of Greenland, they are of a more or less rectangular form, which they retain to some extent as long as they float in the open sea. The tidal currents catch many of the icebergs and carry them into the bays on the Labrador coast, where they are anchored and are carved by the sea into the most beautiful and fantastic shapes conceivable. A frequent form is that of huge cathedral spires, prismed into the most startling and lovely colors known to the eye. The beauty of the coloring is indescribable.

"I photographed many of the most characteristic iceberg shapes, and I shall receive other photographs of them from an English clergyman from Devonshire, who was a fellow passenger on the steamer and came from England especially to photograph the icebergs. I have also made an arrangement with a photographer at St. John's by which I am to receive from his collection of iceberg photographs, gathered in many years, many of the choicest examples. All of the photographs and other data will be used in the lecture on 'Food Fshes from the Sea.'"

The Labrador Esquimaus at Hopedale and Nain were objects of Prof. Bickmore's close attention. He found them closely allied to the Esquimaus of Lapland and Siberia, and regards them as branches of the same stock.

THE MICROBES OF THE SOIL.

IN a recent number of this journal, Dr. Cartaz published an article upon microbes, in which he showed these infinitely small organisms living, or, better, multiplying, in the air and water. We wish now to speak of the organisms that inhabit another element no less important—the earth. In the first place, does the soil contain micro-organisms? The answer is not doubtful. The least particle of earth mixed with water allows us to see under the microscope, aside from the organic and mineral debris, a host of more or less complex organisms moving with varying rapidity. Mr. Reimers, a German author, has calculated that every cubic centimeter of earth may contain several thousand germs. Among these microbes there are some that have not yet been studied, and the role that they play is unknown to us, while certain others possess functions that are well determined. A very simple mode of demonstration consists in reproducing Messrs. Deherain and Maquenne's experiment relative to the presence of butyric ferment in the soil.

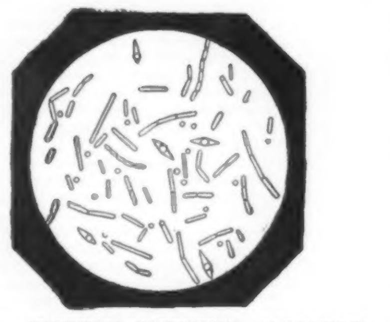


FIG. 2.—BUTYRIC FERMENT OBSERVED UNDER THE MICROSCOPE.

Into a large balloon of about three liters capacity (Fig. 1) there are introduced 100 grms. of cane sugar, 100 of powdered chalk and 100 of garden soil. The balloon is then filled with water and is closed hermetically with a stopper containing an aperture, through which passes a tube that ends beneath a receiver filled with water. This tube should not project beyond the orifice of the cork, in the interior of the balloon. The balloon is then placed in a water bath, which, by means of a gas burner turned low, is kept at a temperature of from 35 to 40 degrees, this being the most favorable one for the development of butyric bacteria. At the end of thirty hours fermentation begins, the liquid in the balloon foams and overflows, and then, a few days afterward, the effervescence ceases. The gases then collected in the receiver by the methods ordinarily employed in laboratories consist in great part of hydrogen mixed with a smaller proportion of carbonic acid. In order to verify this, a piece of caustic potash is introduced into one of the gas bell glasses, which is closed by the hand and shaken.

Upon opening the bell glass under the water, it is remarked that the latter rises to a certain height. After this operation has been repeated two or three times, all of the carbonic acid contained in the bell glass will have been absorbed by the potash. If any sort of a flame be then brought near the glass, the remaining gas will take fire and burn with a pale flame, which characterizes the presence of hydrogen.

The liquid in the balloon, examined under a powerful microscope, exhibits a large quantity of elongated, active vibrios having the form shown in Fig. 2, and constituting the butyric ferment. On leaving things to themselves until all the sugar has disappeared, and on making an analysis of the products formed, we find therein, especially, notable quantities of acetic and butyric acids.

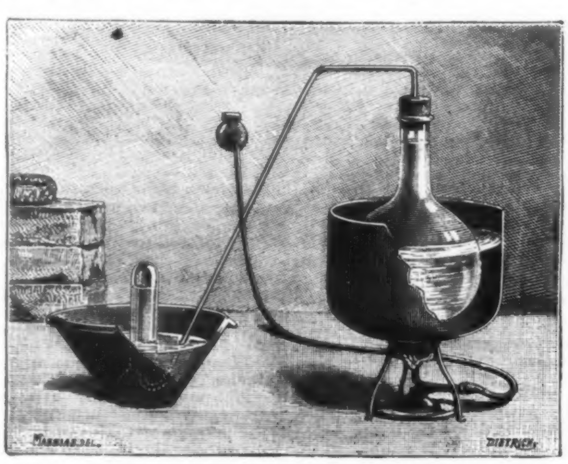


FIG. 1.—APPARATUS FOR DEMONSTRATING THE PRESENCE OF THE BUTYRIC FERMENT IN THE SOIL.

But, in addition to the microbes that bring about such kinds of fermentations, there likewise exist in the earth pathogenic microbes which may prove alarming under certain circumstances. In the first rank of these microscopic but noxious organisms must be mentioned the germs of charbon, septicæmia, tetanus and typhoid fever.

Charbon, the etiology of which has been so thoroughly studied by Mr. Pasteur and his fellow laborers, Messrs. Chamberland and Roux, is one of the most terrible diseases that cattle, and sometimes man even, can be afflicted with. To-day, owing to the studies of the scientists whom we have just mentioned, this affection has become quite rare and is gradually tending to disappear. It was known for quite a long time that charbon was due to a peculiar microbe, but it was not known how it was able to propagate itself. Mr. Pasteur has shown that such propagation has for its cause the longevity of the germs. Thus if the carcass of an animal that died of charbon be put into a trench from one meter to two meters in depth, and be covered with earth, the charbon bacteria will be found in the surrounding earth several years after the burial. It will be understood from this that cattle confined on such ground, or provided with forage derived therefrom, may contract the disease. So when the cause of this scourge was unknown, superstitious countrymen designated such places by the name of "cursed fields."

One may be surprised that the earth, which is so effective a filter, should allow germs to rise to the surface of the ground. Mr. Pasteur has shown that this action is due to earthworms, which are thus the vehicles of the charbon ferment. In fact, we find the bacteria of charbon in the small cylinders of fine earth that the worms leave on the surface and that are spread over the latter by rain. It is therefore necessary to carefully avoid burying animals that have died of charbon on grounds designed for the pasturage of sheep, or gathering forage therefrom. In order to prevent the propagation of germs, and at the same time get rid of the carcasses of the diseased animals, one may operate in two ways, viz., either do the burying in sandy or calcareous earth, which contains but little moisture and is not suited for the existence of earthworms, or, better, as has been recommended by Mr. Aimé Girard, treat the body of the animal with sulphuric acid, which will convert it after a while into a black pulp that may be mixed with fertilizers (such as phosphates, for example) to be spread over the surface of the earth.

Cultivated earth also contains, as we have already said, the vibrio of septicæmia of Pasteur and the bacillus of tetanus of Nicolaier. In fact, Mr. Verneuil has found that inoculations made with such earth develop in animals those two formidable diseases, gangrenous septicæmia and tetanus. Mr. Macé has shown, in an analogous way, that the earth contains the typhoid bacillus.

The fact that the soil contains pathogenic microbes has been taken advantage of by the savages of the New Hebrides (Oceanica) for poisoning arrows, as was stated in a recent number of *La Nature*.

As may be seen, the earth contains a host of microscopic organisms, some of which are dangerous, and many of which are as yet not well known. Now when the earth is dry and is supplying a large amount of dust to the wind, we may ask whether, among these particles thus carried in suspension in the air, there may not exist germs capable of causing diseases such as those that we have just mentioned. Although this question has not yet been studied, it seems, from several examples, that such germs become practically harmless.

In fact, we know that now a large quantity of the sewage water of Paris is spread over the peninsula of Gennevilliers, which has thus been converted into a fertile garden. Now, sewage water contains an incalculable number of microbes, many of which are the germs of formidable diseases, such as cholera, typhoid fever, etc. Fifty thousand cubic meters of such water is distributed over a hectare of land of Gennevilliers. It may be imagined, then, how enormous is the quantity of micro-organisms retained on the surface of the earth. If the fears that one might conceive as to the propagation of diseases were realized, we ought to have observed an increase of mortality among the inhabitants of the peninsula; but, during the twenty years that the earth has been irrigated with sewage water, the death rate has not increased. So, although the question is far from being settled, we may consider that the microbes deposited upon the surface of the earth, and then swept up in a dry state by the wind, are not dangerous.

In addition to the organisms that we have mentioned, the earth contains other ferments or bacteria whose function is entirely different, and which perform a most important role, from the standpoint of vegetable physiology. Thus, Mr. Berthelot has found from a large number of experiments that the earth is capable of fixing the nitrogen of the atmosphere through the intermedium of micro-organisms. Some time ago, Mr. Breal published in this journal a study of the bacteria of the leguminosæ that have this property of assimilating the nitrogen of the air. Finally, the soil likewise contains a nitrifying ferment, on the subject of which some new and very interesting experiments have just been made.—*La Nature.*

OBSERVATIONS seem to show that a decrease in the earth's latitude is in progress, implying an alteration in the direction of the earth's axis. The fluctuation is thought to be due to a minute oscillation caused by some changes in the internal wars of the earth.

THE PROGRESS OF MEDICINE.

THE Bournemouth meeting of the British Medical Association has been, says *Nature*, a great success, and a great deal of useful work and discussion has been recorded. Among the addresses we may refer to the President's (Dr. J. R. Thomson), on the present position of medical officers of health; of Dr. Lauder Brunton, on twenty-five years of medical progress; of Dr. J. Chiene, on rest as a therapeutic agent in surgery; and others on lunacy legislation, the uses and prospects of pathology, etc.

We make the following extracts from Dr. Brunton's address, which presents us with a most admirable and masterly analysis of recent progress:

. . . Perhaps there is no period in the whole history of medicine in which such rapid changes have taken place as in the last five-and-twenty years. It is impossible to give anything like a complete account of these in the brief space of one hour, and I shall therefore restrict myself to a few of the more prominent points, and especially those that have come directly under my personal cognizance; for, like the man who made one-half of his fortune by attending to his own affairs and the other half by leaving other people's alone, I may probably utilize the time at my disposal best by speaking of what I know myself and leaving other things out.

Advances in Knowledge and Teaching due to Experimental Method.—These changes have occurred both in the profession itself and also to some extent—in this country at least—in the education and training of the men who enter it. We notice, first, that a very great increase has occurred in the knowledge of the nature, causation, and treatment of diseases possessed by the profession as a whole, but perhaps a still greater gain is the general adoption of the experimental method by which most of our recent knowledge has been acquired and from which we may hope for even greater advantages in the future. In correspondence with the acquirement of knowledge, we notice also a great alteration in the teaching of medicine, and especially prominent is the tendency to make such teaching practical instead of theoretical by training men to place their dependence upon objective facts, and not to receive without experimental data the theories or speculations of any master, however great he may be. . . .

Direction of Advance.—The greatest advance made in the last twenty-five years has been in the direction of the accumulation, co-ordination, and teaching of facts instead of theories, of the phenomena of nature as opposed to the fancies of the human mind.

Co-ordination of Facts.—But the mere accumulation of facts is of little use unless they can be so arranged, compared and grouped as to bring them into relationship with some general law, and this we find in the world's history has been done from time to time by some master mind. . . .

Influence of Darwin.—Medicine, both in its principles and practice, is really a subdivision of biology, and this, like all other branches of knowledge, has been most profoundly modified by the general acceptance of Darwin's great thoughts—the doctrine of evolution, the struggle for existence, and the survival of the fittest. Wherever we turn we find that Darwin's influence has modified the direction of thought; and whether the study concerns the evolution of the elements, the evolution of the planetary systems, of living beings, of communities, of customs, of laws, of literature, science, or art, in every department of human knowledge we find that men, consciously or unconsciously, are influenced by Darwin's work. It is with shame I confess that five-and-twenty years ago, although I had taken a University degree not only in medicine but in science, and might therefore be supposed to be acquainted with his work, I did not even know of the existence of his "Origin of Species," and I first heard its name in Vienna from the lips of an Austrian who was speaking of it in terms of the highest praise. "What is it?" I asked, and my question then seemed to cause my foreign friend as much astonishment as it causes myself now, when the possibility of such ignorance seems to me, as it must to you, almost incredible, and yet such was the fact. The publication of Darwin's "Origin of Species," in 1859, has done more to change the current of human thought than anything else for centuries, but while its influence is everywhere felt, biology and all its subdivisions have been more especially affected.

Changes in Medical Students.—But great as the changes have been during the last five-and-twenty years in the profession itself, they are perhaps quite as great in the men who enter it. . . .

Long ago the doctor's means of diagnosis consisted in inspecting the tongue, feeling the skin, counting the pulse, shaking the urine, and looking at the motions and the sputum. But now, in addition to a thorough training in auscultation and percussion, students have to learn the use of laryngoscope, ophthalmoscope, and otoscope, and the application of electricity. They have to acquire a knowledge of the chemistry of the urine and its alterations in disease, and, what takes still more time, they have to learn the microscopical appearances, not only of the tissues and excretions in health, but their alterations in disease, and must be acquainted with the methods of staining so as to detect tubercle bacilli and other disease germs.

Departments of Greatest Advance.—Five-and-twenty years ago we knew only too well that typhus was infectious, and that pyæmia and erysipelas were likely to spread in a ward when once they got into it, but we did not know then the causes of these diseases as we do now nor had we the same means at our disposal wherewith to combat them. The departments in which the greatest advances have been made within the last five-and-twenty years are in those of fevers and diseases of the nervous system. A new era in the study of the latter was foreshadowed by the experiments of Fritsch and Hitzig on the brain of the dog, but it can only be said to have fairly begun with Ferrier's localization of the cortical centers, both motor and sensory, in the brain of monkeys. For the brain of the dog was too unlike that of man for experiments upon it to be of much practical use in the diagnosis of human ailments, while the likeness in the brain of the monkey to that of man at once allowed conclusions drawn from the experiments upon the former to be transferred upon the latter. Yet if we try to describe in one word the department in which medicine has made the greatest progress within the last quarter of a century, that word must be "fevers;" for during this time we have learned to recognize fever by the use of the thermometer in a way we never did before; we have learned the dependence of the febrile process in the great majority of cases upon the presence of microbes in the organism, and we have become acquainted with an immense number of chemical substances which have the power both to destroy the microbes and to regulate the febrile process.

Introduction of the Thermometer.—It is true that the thermometer was used by Danielssen, in leprosy, before the year 1848, and its more general use began with Wunderlich's observations nearly thirty years ago, but it is only within the last five-and-twenty years that its use has become at all general. . . .

Nature of Fever.—The thermometer has not only enabled us to detect the onset and to watch the progress of fever, but in conjunction with microscopical research, physiological experiment, and chemical analysis it has enabled us to gain a fuller knowledge of the nature of the febrile process itself. We know that during it the organism is consuming rapidly, or, as Dr. Donald MacAlister graphically says, it is like "a candle burning at both ends," and we have learned scientifically the reasons for the practical treatment, of which Graves was so proud that he wrote as his own epitaph, "He fed fevers." We have learned also, to a great extent, the necessity for the elimination of the waste products, or ashes as we may term them, which the excessive combustion produces, and thus we know why the surgeon is so anxious regarding the result of an operation when the kidneys of his patient are inadequate. For if any febrile attack following the operation should lead to increased demands upon these secreting powers, they might fail to meet it, and the retained excreta would poison the patient.

New Methods.—The rapid increase in our knowledge has been due not merely to the constant use of old methods, but to the introduction of new ones, and more especially to the general recognition of the fact that the same strategy which has often proved so successful in war is to be applied in attacking complex problems. They are to be separated as far as possible into their several components, and each of these is to be overcome in detail. As presented to us by observation at the bedside, the problems of disease are too complex for us to solve, and we are only succeeding in doing it by examining the various factors one by one in the laboratory. The greatly increased powers of the microscope and the better methods of illumination have been of the greatest service, but their utility would be very much less than it is had it not been for the general introduction of the microtome and the invention of new methods of staining. When I was a student the microtome was only used for cutting sections of wood in the class of practical botany. About that time it was employed by Mr. Stirling, Prof. Goodsir's assistant, in the preparation of animal tissues, but I believe that we owe its general introduction to Prof. Rutherford. The facility with which sections are made by it has made microscopical research much less tedious, and has enabled trained histologists to do more work in a given time, and medical students to acquire knowledge more rapidly. But without the method of staining introduced by Weigert and Ehrlich we should, even with the best microscopes, be unable to recognize most of the microbes which are so important in the causation of disease.

Good Out of Evil.—It is very interesting to see how good may come out of evil, and a striking illustration of this is afforded by the history of medicine in the period we are now considering. For it seems to me that we can trace a great part of our knowledge of disease germs and of the antiseptic remedies we use in treatment to the cupidity and stupidity of the Spaniards of the Cordilleras. Their cupidity led them to cut down the cinchona trees of the Andes in order to fill their pockets with the gold they received in exchange for the precious bark, while their stupidity prevented them from planting new trees to replace those which they felled. The consequence of this was that quinine became so dear that it was evident that any one who could produce it artificially would make his fortune. Among others, Perkins tried to do this, and, although he failed, yet in the attempt he discovered the anilin dyes, whose staining powers have not only helped us so much in ordinary histological research, but have made it possible to distinguish disease germs which without them would have been invisible. But the discovery of the anilin colors was only one outcome of the attempt to make quinine synthetically, for the impulse which it gave to the study of aromatic compounds has led to the production of salicylic acid and acetanilide, antipyrin, phenacetin, and all the other antipyretic remedies whose number is probably legion, and whose names already have become so numerous as to be troublesome. Here we see good has arisen out of evil; for if the price of quinine had not been so high, the researches which have proved so useful might not have been begun even yet.

Small and Great, Foolish and Wise.—In looking at the greatest advances which medicine has made—namely, the knowledge of infective disease—we can see how enormous results can arise out of very small beginnings, and the safety of nations may be consequent upon a research which many men would have termed useless or even frivolous. I can hardly fancy any better illustration of St. Paul's observation about the foolish things of this world confounding the wise than Pasteur's researches on tartaric acid; for what could seem more foolish to the so-called practical man than the question, "Why does a crystal of tartaric acid sometimes take one shape and sometimes another?" Yet from an attempt to answer this question has arisen the whole of Pasteur's work on fermentation in general, and on that of wine, beer, and vinegar in particular, whereby he has been able to save millions to his country by accelerating the production of vinegar and preventing the souring of wine and beer. His observation that tartaric acid sometimes turned the ray of polarization to the right, sometimes to the left; that, indeed, there were two crystals apparently alike, but really different; and that these could be combined so as to form a symmetrical crystal having no power of rotation, led him to look to life and living beings as the source of asymmetry. He tried to produce this asymmetry in salts of tartaric acid by fermentation, and found that during the process an organism developed which eats up the dextro-tartaric acid, and leaves the lævo-tartaric acid behind. This led him to investigate such minute organisms, and, by simplifying the soil in which they grew, and separating the organisms one from another, he learned the conditions of their growth, and showed that most processes of fermentation were due to the presence of living organisms. It is true that while Pasteur was still a boy at school, Peyen and Persoz had shown that the liquefaction of starch and its conversion into sugar was due to diastase, and that Dumas in a report on a paper by Guerin-Varry had pointed out that although, unlike diastase, the active principle of the gastric juice had not been isolated, it was probably a ferment of a somewhat similar kind. Dumas classed yeast as a ferment along with diastase, and the fact that such a process as conversion of starch into sugar could be effected without a living organism naturally rendered it all the more difficult for Pasteur to prove his thesis that most fermentations were due to living organisms.

Chemical and Biological Views of Fermentation.—The two views of the action of ferments—namely, the chemical and the biological—may, I think, fitly be likened to Pasteur's two kinds of tartaric acid, each by itself being lopsided and incomplete, forming a symmetrical whole only when united. There can be no doubt of the truth of the chemical view that diastase is not a living organism, and yet converts starch into sugar. There can be as little doubt of the biological view that yeast and other organisms which cause fermentation are living bodies, and that without the presence of these living bodies, alcoholic, acetic, and other forms of fermentation would not exist.

Microbes and Enzymes.—But recently we have come to recognize that these living organisms may produce their effect by manufacturing chemical ferments, and that these ferments may occasionally do the work, although the organisms which form them may be absent. It is quite true that it is difficult—perhaps impossible—to get fermentation from the dead yeast plant, but we may find a parallel for this in the fact that the pancreas of the higher animals sometimes yields an active ferment and sometimes not. Nor need we wonder that the ferments produced by microbes have but a slight action compared with those of the microbes themselves, if we remember how very little power of digestion a dead pig's stomach has as compared with the amount which can be digested, not by the live animal itself only, but by the herds of swine consisting of its "fathers and mothers, its brothers and sisters, its cousins and its aunts," during all the term of their natural lives; for in the process of fermentation microbes are growing, fermenting, and dying with great rapidity, and many generations occur in a fermenting fluid in the space of a few hours, so that the total effect they produce will be out of all proportion to any which can be got from the microbes themselves at a single instant.

Microbes and Disease.—From organisms as a cause of fermentation and of the diseases of wine and beer, Pasteur went on to investigate their action as causes of disease in living beings—first in the silkworm, next in the lower animals, and, lastly, in man. He established the dependence of the silkworm disease and of anthrax upon the presence of specific microbes which could be transmitted and communicate the disease, and by destroying the infected eggs of the silkworm he eradicated the disease and restored the silk industry to France.

Weakening of Disease Germs.—But while this investigation is interesting to us as illustrating the probable cause of the disappearance of typhus fever, to which I have already alluded, Pasteur's researches on anthrax are still more important as bearing upon the question of protective inoculation; for he found that the disease germ could be cultivated outside the living body and grown in flasks under varying conditions, some of which were favorable and others unfavorable to its growth. High temperature enfeebled the virus, so that it no longer killed an animal with the same certainty, and by inoculating first with a weak virus and then with one successively stronger and stronger, he found that animals could be completely protected either from inoculation by the strongest virus or by infection from other animals suffering from the actual disease.

Increase in Virulence of Disease Germs.—Another extraordinary fact which he made out was that the virus thus weakened, so that it will not kill a guinea pig a year old, and still less a sheep or ox, may again be rendered most potent by inoculating a feeble animal, such as a guinea pig a day or two old, from this older and stronger guinea pig's, the strength of the disease germs increasing with every inoculation, until finally sheep and cows may be killed by it. We can thus see how an epidemic of disease beginning sporadically, and attacking weak individuals, may gradually acquire such strength as to attack and carry off the strongest.

Pure Cultures.—Pasteur's plan of growing disease germs outside the body in broth, although of the utmost value, did not allow a convenient separation of different germs; but this can now readily be done by Koch's plan of sowing them, not in a liquid medium, but on solid gelatine spread on glass plates, so that the growth of the germs can be daily watched under the microscope, and inoculations made from single colonies on other plates until pure cultures have been obtained. By thus isolating the different microbes, we learn their life history, the mode in which their growth is influenced by differences of soil, of temperature, of moisture, by the addition of various substances which either favor or retard their growth, and, last but not least, the effect which one microbe has upon another when they are grown together at the same time.

Struggle for Existence among Microbes.—For even among these minute organisms the struggle for existence and the survival of the fittest exists, like that which Darwin pointed out so clearly in the case of higher plants and animals. . . .

Struggle for Existence between Microbes and the Organism.—But it is not merely between different species of microbes or different cells in an organism that this struggle occurs. It takes place also between the disease germs and the cells of the organism which they invade, and the result of the struggle may be determined, not by some powerful agency which weakens or destroys either the organism or the microbe, but by some little thing which simply inclines the scale in

favor of one or the other. Thus, in the potato disease, the victory of the invading microbe and the destruction of the potato, or the death of the microbe and the health of the tuber, may depend upon some condition of moisture or possibly of electrical change in the atmosphere which aids the growth of the microbe disproportionately to that of the potato. These atmospheric conditions need not necessarily be antagonistic to the potato. They may even in themselves be advantageous to it; but if they help the microbe more than the plant, the microbe will gain the victory and the plant be destroyed.

Fight between Cells in Higher Organisms.—The fight between the organs which Æsop describes in his fables actually occurs between the cells in some vertebrate animals, and the schism predicted by St. Paul as the result of such a fight actually takes place. For in the tadpole, at one stage of its existence some of the cells at the base of the tail begin to eat up others, with the result that schism occurs and the tail falls off.

Phagocytosis.—This struggle for existence between the cells of an organism and microbes has been beautifully shown by Metschnikoff in the daphne or water flea, where the process of the cells eating up the microbes or the microbe destroying the cells can be actually observed under the microscope. This process of phagocytosis is now regarded by many as only a small part of the struggle between an organism and a microbe, but it is impossible to see one part of a microbe half digested by the cell in which it is embedded, while the part outside remains unaltered, without believing that the process is one of great importance. At the same time, it seems that the process of phagocytosis, where the microbe and the cells meet in close conflict, bears about the same relationship to the total struggle that a bayonet charge bears to a modern battle. The main part of the fight is really carried on at some distance by deadly weapons—by bullets in the case of the soldier, and by ferments, poisonous albumoses, and alkaloids on the part of the cells and the microbes. In some of Metschnikoff's observations we can almost see this process, for he has figured leucocytes dead, and apparently burst by the action of conidia, lying close to but yet outside them, as if these conidia, like the dragons of fable, had spit out some venom which had destroyed them.

Venom of Microbes.—Within the last few years attention has been gradually becoming directed less to microscopical examination of the microbes themselves and more to chemical investigation of the ferments and poisons which they produce; yet, strangely enough, the very moment when chemistry is becoming more important than ever has been chosen to minimize the teaching of it in medical schools, and examination in it by licensing bodies. It is now possible to separate the albumoses and poisons from the microbes which produce them either by filtration or by destroying the microbes by graduated heat; for, as a rule, they are destroyed by a lower temperature than the albumose or poisons which they form.

Microbes and Enzymes.—As the albumoses produced by microbes are nearly allied, chemically and physiologically, to those formed in the alimentary canal of the higher animals by digestive ferments, it is natural to suppose that microbes, like the higher animals, split up proteids, starches, and sugars by enzymes, which they secrete, and which in both cases may be obtained apart from the living organisms which produce them; that, in fact, we should be able to isolate from microbes bodies which correspond to pepsin or trypsin, just as we can isolate these from the stomach or pancreas of an animal. In some, although not in all cases, this attempt has succeeded.*

Poisonous Albumoses.—The albumoses produced by microbes resemble those formed during normal digestion in being poisonous when injected directly into the circulation, although they may not be so greatly absorbed from the intestinal canal. One of the most remarkable discoveries in regard to albuminous bodies is the fact that some of them which are perfectly innocuous, and, indeed, probably advantageous to the organism in their own place, become most deadly poisons when they get out of it. Thus, the thyroid and thymus glands, which are perfectly harmless and probably useful, were found by Wooldridge, when broken up in water, to yield a proteid which instantaneously coagulated the blood if injected into a vein, so that the animal died as if struck by lightning; while Schmidt-Muhlheim, under Ludwig's direction, found that peptones had an exactly opposite effect, and prevented coagulation altogether.

Neutralization of Poisonous Albumoses.—Perhaps the analogy is too vague, but we seem to find here something very like Pasteur's two kinds of tartaric acid, one rotating polarized light to the right, the other to the left, but when united together, having no action at all, for here we have two bodies, one of which destroys coagulability entirely, the other increases it enormously; while many albuminous bodies have no action upon coagulation whatever. This view would lead us to suppose that one form of albumose may neutralize the action of another, thus rendering them both completely innocuous, while either one or other alone might be a deadly poison. The albumoses formed by microbes appear frequently, if not always, to have a double action, destructive and protective, on the higher animals. Pasteur's treatment of hydrophobia is based on the idea that the spinal cord of rabid animals contains a virus and its antidote; Koch's tuberculin may be similar in this respect, and may yet, by suitable alterations, fulfill the hopes of its able and single minded discoverer.

Zymogens and Enzymes.—Perhaps a similar process of splitting up and recombination may explain the formation and disappearance of the enzymes, such as pepsin and trypsin, by which digestion is carried on. The pancreas of a fasting animal will not digest albuminous bodies like fibrin, while the pancreas of an animal killed during full digestion will do so rapidly. Yet the fasting pancreas contains the zymogen, or mother substance, which yields the digestive ferment, and, as Kuhne has shown, by treating it first with acid and then with alkali, it becomes active. Again, to recur to the analogy of Pasteur's tartaric acid, we seem to find that the inactive, and possibly symmetrical, albuminous substance of the fasting pancreas is split up by this treatment after death or during the process of digestion in life, and yields the lopsided and active pancreatic ferment. But, if this be so, what becomes of the other half which has been split off? We do not at present know, but curiously enough Lepine has lately shown that while the pancreas is pouring into the digestive canal a ferment which will form sugar, it is at the same time pouring into the circulation another ferment which will destroy sugar.

Immunity.—We must be very careful in our speculations, and test them by experiment, but such observations as these may tend to throw some light upon the nature of immunity. Immunity is probably a very complex condition, and is not dependent altogether upon any single factor, but we can now understand that if a microbe has gained an entrance into an organism, and produces a proteid or an albumose poisonous to the organism which it enters, it may grow, thrive and destroy that organism, while the injection of some other proteid which would neutralize the poison might save the animal, while the microbe would perish.

Cure of Anthrax.—Thus Hankin has found that, while a mouse inoculated with anthrax will die within twenty-four hours, a rat resists the poison altogether; but if the mouse after being inoculated with the disease has a few drops of rat's serum injected into it, instead of dying, as it would otherwise certainly do, it survives just like the rat, and from the spleen of the rat Hankin has isolated a proteid which has a similar protective action to that of the serum.

Cure for Tubercle.—Working on similar lines, Bernheim and Lepine used the injection of goat's blood in phthisis so as to stop, if possible, the progress of tubercle, and Richet has used the serum of dog's blood, for the goat is quite immune, and the dog is to a great extent, though not entirely, immune from attacks of tuberculosis. The injection of goat's blood in somewhat large quantities has been given up, while dog's and goat's serum in small quantities of 15 to 20 minims at intervals of several days is still under trial.

Action of Blisters.—But if immunity can be insured by such slight changes in the organism as a few drops of serum from a rat will produce in the body of a mouse, it is natural to suppose that a similar change might possibly be effected by removing the albuminous substance from one part of the body, and introducing it, perhaps after it has undergone slight change, into another. As I have already mentioned, the albumoses of ordinary digestion are poisonous when they are injected into the circulation, and so are the proteid substances obtained from the thyroid and thymus glands. Why, then, may not the serum of one's own blood, withdrawn from the vessels by a blister and reabsorbed again, be as good as the serum obtained from the blood of an animal? . . .

Bleeding.—It is quite possible, too, that the good effects of bleeding may be due to a similar cause. . .

Speculation and Experiment.—The human body is a most complex piece of mechanism. We learn its action bit by bit very slowly indeed, and we are only too apt to regard the little piece which attracts attention at the moment as all important and to leave the other parts out of sight. But this is not true of our study of the body only, for the same tendency manifests itself in the pursuit of knowledge of all kinds, yet it is in medicine more especially that this tendency comes to be a matter of life or death, for upon the medical view prevailing at the moment medical practice is apt to depend, and erroneous views may lead to the death of many patients. So long as practice depends upon theories, unchecked by experiment, so long will medical practice prove fluctuating, uncertain and dangerous. One of the greatest gains of the last five-and-twenty years is the general introduction of the experimental method, and the habit which has been growing up during it of accepting no statement unless based upon experimental data. Speculations such as those in which I have been indulging in regard to blisters and blood letting are useful as indicating lines of experimental research, but until these have been thus tested it is foolish and may be dangerous either to accept and act upon them as true or to scout them entirely as false and absurd. Imperfect knowledge is almost sure to lead to one-sided practice, and thus, diverging further and further from the truth, ends at last in falsehood and folly.

Antisepsis.—Perhaps no better example of this can be found than antiseptic surgery, from the time of the good Samaritan down to Ambroise Paré and Sir Joseph Lister. The good Samaritan bound up the wounds of the poor traveler, pouring in oil and wine, which, only a few years ago, was recommended in an Italian journal as an excellent antiseptic. Ambroise Paré, when his ointments ran out, could not sleep for thinking of the miserable soldiers to whom they had not been applied, and was greatly astonished to find in the morning that these wretched, neglected ones were better and happier than their comrades who had been treated *secundem artem*. I have no doubt that Paré's predecessors, in trying to improve upon the methods of the good Samaritan and upon the still useful friar's balsam, which is a powerful antiseptic but stings the wound or sore, had tried to make their applications more and more irritating, not knowing that it was the antiseptic power and not the irritant qualities which were desired. Paré abolished the ointments with the irritation they caused, and thus did great service to surgery. But a greater one yet was rendered by Lister when he recognized that the danger of operations was due to the entrance of germs, and by preventing this has completely revolutionized surgical practice; nay, more, he has to a great extent revolutionized medicine, for the diseases of the internal organs, which were formerly entirely under the physician's care, are now becoming amenable to surgical treatment, and diseases of the stomach, intestine, liver, kidney and lungs, and even of the brain and spinal cord, are now successfully treated by surgery when medicines are powerless to help. The most remarkable of all the recent triumphs of surgical operations upon the brain in which Mr. Horsley has gained such well deserved fame would have been impossible without Ferrier's localization of cortical centers, and would have been equally impossible but for Lister's antiseptic method.

Disinfection.—But it is not only in surgery that recognition of diseased germs as a source of danger to the organism has led to their destruction outside the body, and insured safety from their attack. This occurs in all infective diseases, and this term now includes many which were not formerly regarded as such, for neither consumption nor pneumonia was formerly regarded in this light; but just about twenty-five years ago tubercle was shown to be inoculable, and since then the discovery of the bacillus of tubercle by Koch, and of pneumonia by Friedlander, has caused us to class both these diseases as not only infective, but as caused by definite organisms.

Prevention of Epidemic Diseases.—So long as people were ignorant of the causes of epidemic diseases, they were utterly unable to combat them, and they either in fury slew defenseless people for poisoning the wells, as in the middle ages, or appointed days of fasting and prayer, as in our own times. But once an epidemic is known to depend upon the presence of a certain organism, precautions can be taken for destroying the organism outside the body by means of disinfectants, or for lessening the susceptibility of the organism to its ravages inside the body by inoculation, or combating its effects by means of antipyretics. A knowledge of the life history of microbes has enabled us to ascertain the power of different substances, either to destroy them completely or to arrest or retard their germination and growth, and in this way to prevent the occurrence of the diseases which these microbes might otherwise produce. . . .

Antivivisection.—Every now and again a loud outcry is raised against this method, partly from ignorance and partly from prejudice. Many—probably most—of the opponents of experiments on animals are good, honest, kind-hearted people, who mean well, but either forget that man has rights against animals as well as animals against man, or are misled by the false statements of the other class. These are persons who, blinded by prejudice, regard human life and human suffering as of small importance compared with those of animals, who deny that a man is better than many sparrows, and who, to the question that was put of old, "How much, then, is a man better than a sheep?" would return the reply, "He is no better at all." Such people bring unfounded charges of cruelty against those who are striving, to the best of their ability, to lessen the pains of disease both in man and also in animals, for they, like us, are liable to disease, and, like us, they suffer from it. I may perhaps be allowed to quote two sentences from a paper which I wrote twenty-four years ago, and therefore a considerable time before any antivivisection agitation had arisen, for they expressed then, and they express now, the objects of experimental pharmacology: "Few things are more distressing to a physician than to stand beside a suffering patient who is anxiously looking to him for that relief from pain which he feels himself utterly unable to afford. His sympathy for the sufferer, and the regret he feels for the impotence of his art, engrave the picture indelibly on his mind, and serve as a constant and urgent stimulus in his search after the causes of the pain, and the means by which it may be alleviated" (*Lancet*, July 27, 1867).

Gains by Experiment on Animals.—It is said that our mouths are full of promises, but our hands are empty of results. The answer to this is that any one who doubts the utility of experimentation upon animals should compare the *Pharmacopœia* of 1867 with our present one. To it we owe, in great measure, our power to lower temperature, for to it is due not only the introduction of new antipyretics, such as salicylate of soda, antipyrin, antifebrin and phenacetin, but the extension of the use of quinine from a particular kind of fever—malaria—to other febrile conditions. To it also we owe our greatly increased power to lessen pain by the substances just mentioned, which have not only an antipyretic but an analgesic action, and give relief in the torturing pains of neuralgia and locomotor ataxy when even morphine fails to ease, unless pushed to complete narcosis. The sleeplessness, too, which is such a frightful complication in some fevers, can now be combated by other remedies than opium and antimony; and we have the bromides, chloral, sulphonal, paraldehyde, urethane, chloralamide and others, which, either by themselves or added to opium, enable us to quiet the brain instead of exciting it to further action, as opium alone so frequently does. Our whole ideas regarding cardiac tonics also have undergone a complete revolution within the last quarter of a century, for I was told, when a student, that digitalis was a cardiac sedative, and was apt to depress the heart, whereas now we know that it and its congeners—strophanthus and erythrophlœum and spartein—increase the heart's strength, raise the vascular tension, and are useful not only in sustaining the circulation, but in aiding elimination. This view of the action of cardiac tonics, which has revolutionized the treatment of heart disease, we owe chiefly to the experiments of Traube, although my own experiments, made in the laboratory of Sir Douglas Maclagan under the direction and by the help of my teacher and friend, Dr. Arthur Gamgee, may have helped toward its general acceptance in this country.

Future of Pharmacology.—But perhaps the most promising thing about pharmacology is that we are now just beginning to gain such a knowledge of the relationship between chemical structure and physiological action that we can, to a certain extent, predict the action of a drug from its chemical structure, and are able to produce new chemical compounds having a general action such as we desire; for example, anæsthetics, soporifics, antipyretics, analgesics; although we have not yet arrived at the point of giving to each one the precise action which would make it most suitable in any particular case. Even when we do not know the chemical structure of a drug, we may be able, from noticing one of its actions, to infer that it possesses others. We are, indeed, getting a knowledge of the action of drugs both of known and unknown chemical structure, and a power of making new remedies which will, I believe, enable us within the next five-and-twenty years to cure our patients in a way that at present we hardly think. . . .

THE influence of food upon the rate of formation of carbonic acid has been made a matter of study in France, and it has been found out that during the first hour after a meal the quantity of carbonic acid exhaled increases till it reaches a maximum, three or four hours after the meal, when it falls off again. Plenty of fresh air is desirable from one to three hours after a meal.

* *Vide* Brunton and Macfayden, Croonian lectures on "Chemical Structure and Physiological Action." *British Medical Journal*, June 15, 1889, p. 1333.

ODOROUS WOODS.

By JOHN R. JACKSON, Curator of the Museums, Kew.

PERHAPS the most important of all fragrant woods is sandal wood, and this term, under which the wood is known in commerce, is applied to the woods of a number of plants belonging to widely divergent natural orders, and found in widely separated parts of the world. The principal and most important sandal wood is that obtained from *Santalum album*, L., a small tree, 20 or 30 feet high, of Southern India, Mysore, Coromandel coast, Madura, etc. It is also found in Eastern Java, Timor, Sumba, or Sandal Wood Island, and other parts of the Malay Archipelago. Government plantations have been formed in India, in the Madras Presidency, and Mysore. The tree is evergreen, flowering and fruiting nearly throughout the year. In India the best wood is obtained from trees of about 20 to 30 years old, the trunks of which are about a foot in diameter. The trees are either felled or dug up by the roots, the smaller branches are lopped off, and the trunk is left on the ground for some months so that the sapwood, which is of no value, may be destroyed by white ants, when it is trimmed and sawn into billets, varying from 2 to 4 feet long and 3 to 8 inches in diameter. After being conveyed to the depots, the wood is more carefully overhauled, again trimmed, and sorted into qualities. It is said that about 13,000 tons of sandal wood are annually cut in India, for internal use and for exportation, the value of which amounts to about 50,000*l.* Large quantities are exported to China and Arabia. The principal uses of sandal wood are for carving, the preparation of incense, and for perfumery. After removing the sapwood, the heartwood is seen to be of a yellowish brown color, with somewhat darker concentric rings. The sapwood has no smell, while the heartwood has a very powerful and agreeable odor, and a strong aromatic and bitterish taste, due to the presence of an essential oil which is distilled in large quantities in India. Both the quality and quantity of sandal wood oil varies much, according to the nature and character of the wood. Though sandal wood has long had a reputation in the East, as a remedy in fevers, indigestion, and many other affections, and though it is still largely used medicinally, the principal applications of the wood are for the distillation of the oil, for carving, and in China and India for burning as incense in temples; indeed, in China alone, the quantity of sandal wood imported, of all kinds, amounts, it is estimated, to 5,000 tons, representing a money value of about 100,000*l.*

So much has been written, and written so well, on the subject of sandal wood, in Fluckiger and Hanbury's "Pharmacographia," and in the *Pharmaceutical Journal*, by MacEwan, Kirkby, and Holmes, that it is unnecessary to repeat it here. It may, however, be well to give the names of the species of *Santalum* that yield the different kinds of sandal wood, as stated by Mr. Holmes, in his paper on the subject, at p. 819, *Pharmaceutical Journal*, vol. xvi., 3d series, 1886:

Santalum Freycinetianum, Gaud., and *S. pyrularium*, A. Gray, yield Sandwich Island sandal wood.

S. insulare, a native of the Marquesas and Society Islands, is said to have been observed by Captain Cook to be used by the Tahitians for scenting cocoa nut oil.

S. Yasi, Seem, yields Fiji Island sandal wood, and *S. austro-caledonicum*, Viell, New Caledonian sandal wood.

Fusanus spicatus, R. Br., furnishes West Australian sandal wood. Referring to this species, Mr. Maiden in his "Useful Native Plants of Australia," says: This sandal wood forms an important article of export from Western Australia; the amount exported in 1884 being valued at 29,960*l.*, of which this wood formed a considerable portion. China is the chief market for it. In 1849, 1,204 tons of sandal wood, valued at 10,711*l.*, were shipped from Western Australia. The merchants bought it for shipment at 6*l.* to 6*l.* 10*s.* per ton. Now, the sandal wood trees of any size, within a radius of 150 miles of Perth, have been cut down, and little can be obtained, except at a great distance. In 1876, 7,000 tons were exported, of the estimated value of 70,000*l.* The amount exported in 1879, chiefly to China and Singapore, was 4,700 tons, valued at 47,000*l.* *Fusanus persicarius*, F. Muell, is also known as native sandal wood.

The source of the woods known as West Indian and Japanese sandal wood is still unknown. The former, which is also known as Venezuelan sandal wood, is considered both by Mr. Holmes and Mr. Kirkby as belonging to the Rutaceæ.

Among other plants which bear the name of sandal wood may be mentioned the following:

1. *Plumieria alba*, L., a small apocyneous tree, native of the West Indies. This is said to be sometimes used as a substitue for true sandal wood, in the color of which it is somewhat similar, but the samples I have had the opportunity of examining have no smell.

2. *Exocarpus latifolia*, R. Br., a small tree belonging to the same order as the true sandal, and very widely dispersed through Australia, Queensland, and the Eastern Archipelago to the Philippine Islands. This is known in Australia as the broad leaved cherry, and scrub sandal wood. The wood is described by Mr. Maiden, in his "Useful Native Plants of Australia," as very hard and fragrant, dark colored, coarse grained, and excellent for cabinet work.

3. *Carissa sechellensis*, Baker.—A tree 30 or 40 feet high, native of the Seychelles, where it is now rare, and known only in Silhouette, but said to have been once common in the northern forests of Mahe. The wood is similar in appearance to sandal wood. *C. Xylopicron*, Thouars.—A shrub or low tree of Mauritius and Rodriguez, and also found in Bourbon and Madagascar. The wood is similar in appearance to the last. It has no smell. Both these species are known as "Bois Sandal," and belong to the natural order of Apocynaceæ.

4. *Eremophila Mitchelli*, Bth.—A tall shrub or small tree, 10 to 30 feet high, belonging to the Myoporineæ, and found in Queensland and New South Wales. The wood, which is very hard, is of a brown color, beautifully marked, and very fragrant. "Owing to its strong aromatic odor, resembling that of sandal wood, furniture made of this timber is said to be free from the attacks of insects." It is known in Australia under the names both of sandal wood and bastard sandal wood. In the "Proceedings of the Linnean Society of New South Wales," vii., 574, Tenison-Woods writes as follows: "It is said that this wood will keep away the *blatta*, or cockroach. I cannot confirm this statement. I had a good sized billet cut and planed, and the odor from it was so strong as to perfume one of my trunks in which it was placed, but the cockroaches treated it with the utmost disdain. They ran over it, and laid their eggs under it, just as if it had been put there for their accommodation." A closely allied species—namely, *E. bignoniæflora*, F. M.—is a strongly scented small tree or shrub, native of Queensland, New South Wales, Victoria, and North Australia. The heartwood is of a darkish green color, beautifully marked, and is highly fragrant. It does not, however, seem to be known as a sandal wood.

5. *Myoporum platycarpum*, R. Br.—An Australian tree belonging to the same natural order as the preceding. It is known under the name of sandal wood in some parts of Australia, and the wood is of a light walnut color, fine grained, and beautifully mottled. When freshly worked it gives off a very pleasant perfume.

6. *Croton*, sp.?—Under the name of "Santal Vert," a very dense, close grained, and heavy wood of a dark green color is exported from Madagascar and Zanzibar into India, where it is said to be used in funeral piles for burning the bodies of Hindoos. This wood has never been scientifically identified, but it is thought to be a species of *Croton*. There is a specimen of this wood in the Kew Museum, and also some weather worn pieces from Eastern Africa, almost identical in structure with the foregoing, and called African green sandal wood. It has a faint smell of true sandal, and it is said to be ground and mixed with water and used by the natives of Inhambane to anoint themselves. Another specimen is labeled "Muconiti," and was collected by Sir John Kirk when attached to the Livingstone expedition in 1860. It is described as fragrant and durable, containing when fresh a milky juice. It agrees in every respect with the former wood.

7. *Epicharis* (*Dysoxylum*) *Loureirii*, Pierre, and *E Baillonii*, Pierre.—These, belonging to the natural order Meliaceæ and growing in Yunnan and Cochin China, are stated by Baillon to be sources of sandal wood. There is a specimen of the former in the Kew Museum, and it has the odor of true sandal.

Besides these the false sandal wood of Crete is said to be the produce of *Quercus abelicea*, which is described as being of a reddish color and possessing an agreeable fragrance. The terms red sandal wood and red sanders wood are also applied to the woods of two Indian trees, namely, *Adenanthera pavonina*, L., and *Pterocarpus santalinus*, L., but neither of these woods has any fragrance.

Turning now to other fragrant woods, perhaps the best known and most important is camphor wood, the produce of *Cinnamomum camphora*, Nees, a tree of China and Formosa, whence we obtain the well known article camphor, which is procured by cutting down the trees, chopping up the wood into chips, and subjecting them to a process of distillation. The camphor being contained naturally in the wood causes the wood itself to be valuable for entomological and other cabinets, in consequence of the useful and agreeable odor it emits.

The odor of musk, though distinctly marked in the well known garden plant *Mimulus moschatus*, as well as in the seeds of the musk mallow (*Hibiscus Abelmoschus*, L.), is not very commonly found in the vegetable kingdom. The best known instance of its presence in timber is perhaps the Australian musk wood (*Olearia argophylla*, F. M.), a small tree belonging to the natural order Compositæ and found in Tasmania, Victoria, and New South Wales. Besides having a very pleasant musky fragrance, the wood is beautifully mottled, of a brown color and is well adapted for cabinet work, turnery, and perfumery purposes. Another musk tree is *Marlea vitiensis*, Benth., a native, as its specific name implies, of Fiji, but found also in Australia. The tree belongs to the natural order Cornaceæ, and has a close grain wood of a bright yellowish color, with a dark center and a distinct musk-like smell.

The wood of *Bursaria spinosa*, Cav., a tree belonging to the order Pittosporeæ and widely distributed in Australia, where it is known as the native box, is described as having a very agreeable fragrance, which, however, is not lasting. Under the name of Tonga bean wood, the small stem of *Alyxia buxifolia*, R. Br., is known in Australia. The plant is a straggly seaside shrub, and its wood, which is of a brown color and very close grained, smells strongly of coumarin or tonquin bean.

Among other Australian woods noted for their fragrance may be mentioned *Frenela robusta*, A. Cunn, and its variety, *verrucosa*, better known, perhaps, under the respective names of *Callitris robusta* and *C. verrucosa*. These trees belong to the natural order Coniferæ and have a peculiar camphoraceous odor distinct from that usually possessed by coniferous woods. They are, indeed, sometimes known in the colony as camphor woods, and they are said to be obnoxious to insects.

By far the most important o. the scented Australian woods, however, is that known as Myall, or Violet wood, which is the produce of *Acacia homalophylla*, A. Cunn. The beautifully marked dark brown wood is valued equally for its solidity and fragrance, and as most of our readers know, is now very extensively used in the manufacture of tobacco pipes. The dust of this wood collected after sawing makes a simple and excellent sachet powder, retaining its refreshing, agreeable smell for a long time. The following statement by Mr. Maiden regarding the tree itself is not a little remarkable. He says: "The smell of the tree when in flower is abominable, and just before rain almost unbearable, and on this sign people frequently foretell the approach of rain. I have heard of instances in which men who were employed in cutting down a tree of this species just before rain became so sick as to be compelled to leave the tree." The violet scent of the wood is not confined to this species, but is found also in *Acacia glaucescens*, Willd., and *A. harpophylla*, F. M. Another very distinctly perfumed acacia wood is that of *A. acuminata*, Benth., a native of Western Australia, which has a strong scent of raspberries.

Probably the best known scented woods, and certainly the most lasting of perfumes, is the well known Eagle wood, or Lign Aloes, as it is sometimes called, furnished by *Aquilaria Agallocha*, Roxb., a large evergreen tree of Eastern Bengal, Burma, the Malay Peninsula and Archipelago. The wood is known by the Burmese as "Akyau," and by the Malays as "Kayu Garu." It is described as the most important product of the forests of South Tenasserim and the Mergui Archipelago. It is found in fragments of various shapes and sizes in the center of the tree, and usually, if not always, where some former injury has been received. To collect it the trees are felled and allowed to rot for about three years in the forest, when they are again visited, the trees cut into fragments, and the harder and darker colored odoriferous wood cut out. Whether this particular species yielded the Calambac or Agallochum of the ancients is a matter still in doubt. Anyhow, we know that the wood is very highly perfumed, that it contains much oil, which is expressed in India, and that the perfume is most durable. This is abundantly proved by a sample of the wood contained in the museum at Kew, which was brought from Arabia, and formed part of a quantity carried by the pilgrim caravan from Mecca to Damascus, to be used in the manufacture of rosaries. This specimen has been in the museum since 1853, and still retains its very powerful odor.

Another wood which possesses a very agreeable fragrance is that known as Linaloa, or sometimes called Lign Aloes, a product of Vera Cruz, in Mexico. Under the name of *Bois de citron du Mexique*, Guibourt, in his "Histoire des Drogues," refers to this very interesting wood. The wood attracted some attention in this country in the early part of 1869, when it was brought over in the form of squared logs. It is of a lightish color, with dark lines or markings, and has a very powerful fragrance, due to the presence of an essential oil. This oil was first offered for sale in London in 1865 or 1867, and was attributed at the time by Mr. James Collins to a species of *Bursera*, and has since been referred to *Bursera Delpechiana*, of Poisson. Dr. Piesse, in his "Art of Perfumery," says by the distillation of 100 lb. of the broken wood he procured several ounces of otto, which was perfectly white in color, and appeared unalterable by the action of air. It so much resembles the sweet odor of the flowers of the lime tree that, when properly diluted with spirit, and with the addition of a little rose, it makes an excellent imitation perfume of lime blossom. When otto of linaloa is combined with soap, it loses odor rapidly, showing some action by alkalies. It imparts its scent very satisfactorily to oil and grease.

Under the name of "Cedar," several scented woods are often confused. The true cedar is, of course, the cedar of Lebanon (*Cedrus Libani*, Loud.), the wood of which is not sufficiently common that it could be used in large quantities for the purpose of distilling oil. The West Indian cedar (*Cedrela odorata*, L.) is sufficiently abundant to supply the market with any quantity that might be desired, its wood being extensively used for making cigar boxes; but though the wood has an odor somewhat resembling the cedar of commerce, it is not so distinctly marked as to cause a demand to arise for it, more especially as the commercial cedar (*Juniperus virginiana*, L.) is regularly imported from America for pencil making, the shavings and chips from which manufacture yield by distillation otto of cedar. The ground wood is frequently used in the composition of sachet powders, and slips of the wood are used as matches for lighting lamps, etc., in consequence of the fragrance emitted while burning. Pieces of the wood are also frequently used to place in clothes drawers to keep away moths.

Under the name of Rhodium, or Lignum Rhodium, a sweet smelling wood was formerly known, and had a high reputation. It is said to be furnished by *Convolvulus scoparius*, a native of the Canary Islands and Teneriffe. The wood, which is of a lightish color, is extremely close grained, hard, and dense, and contains an oil which has a resemblance to the fragrance of the rose, and is procured from it by distillation. Piesse says that this oil of rhodium was chiefly used for adulterating real otto of rose, but as geranium oil answers so much better, the oil of rhodium has fallen into disuse. One hundredweight of the wood is said to yield only about 3 oz. of oil. The ground wood is used in the preparation of sachet powders.

Several other woods might be enumerated that are usually described as fragrant, such as rosewood, Pallisandra wood, some of the South American species of *Icica*, etc., but a great deal of uncertainty attends the proper identification of these woods, and they are, for the most part, doubtfully scented woods. Turning, then, from those that are agreeable to the sense of smell to those whose odor is unbearable, perhaps the best known is that which possesses the very correct and characteristic name of Stink wood. It is the product of a large tree of Natal and the Cape of Good Hope—*Ocotea* [*Oreodaphne*] *bullata*, Nees ab E., belonging to the natural order Laurineæ. Three varieties of the wood are described as being known at the Cape—one white, one mottled, and the other nearly black; differences that are said to be due to the conditions under which the trees grow. The wood is considered almost equal to teak in strength and durability, and is much used in Natal for building purposes, wagon work, cabinet making, etc.; when freshly cut, however, the wood emits an abominable effluvium. The tree is said to have become very scarce in the forests where it once was abundant. The further destruction of the trees, however, is now prevented by authority.

Quite recently some attention has been given by Professor Dunstan to the wood of *Celtis reticulosa*, in a sample of which obtained by him from the museum of the Pharmaceutical Society he discovered skatol. Professor Dunstan's paper, which was communicated to the Royal Society, is reprinted in the *Pharmaceutical Journal* for June 15, 1889 (p. 1010). *Celtis cinnamomea*, Ldl. = *C. dysodoxylon*, Thw., is a tree found in Sikkim Himalaya, Assam, Chittagong, Burma, Ceylon, Malay Islands, etc., and has a wood that, when freshly cut, according to Thwaites, "possesses a powerful and very disgusting odor." A dried trunk of the wood, received at Kew, however, possessed not the slightest smell of any kind, so that it would seem that the odor, as described by Thwaites, is present only in the fresh wood.

Under the name of *Saprosma fœtida*, a sample of wood has recently been received at the Kew Museum, the disgusting smell of which exceeds either of the preceding. *Saprosma* is a genus of rubiaceous shrubs,

natives of tropical Asia. Of the eight described species, seven grow in India, and *S. fragrans*, Bedd., and *S. ceylanicam*, Bedd., are described in the "Flora of British India," on the authority of Beddome, the former as "fœtid when crushed," and the latter as "very fœtid."

Though the fruits and woods of the several species of *Saprosma* are generally known to possess a disagreeable smell—which, indeed, is indicated by the generic name—it does not seem that the cause of the odor has ever been scientifically investigated.

The subject of odorous woods is such an extensive one that it is hoped these scattered notes may lead to a more careful examination, at least, of some of them.

AMATEUR'S WAY OF ROOTING CUTTINGS.

A BRIEF note on rooting cuttings in an ordinary tumbler with a wad of cotton batting in the bottom appeared in an earlier number of *Popular Gardening*. This method proves to be an easy and convenient one for the amateur having only a few cuttings to strike at a time, and not always the necessary conveniences, propagating bench, sand, etc., at command. During April we received some choice tomato plants by mail, which were all broken up, so that only a few of the tips were in good shape. These inserted in cotton batting in a tumbler in same way as geranium and coleus cuttings, etc., are shown in illustration on this page, and placed in the windows of the sitting room, soon emitted healthy, fibrous roots, although left entirely without attention, and no water was applied after the first thorough soaking given to the cotton batting. These plants were set into open ground directly after taken out of the tumbler, and are now as large and thrifty plants as any we can show that were grown from seedlings. It is wonderful how long

ROOTING CUTTINGS IN COTTON BATTING.

cotton batting will remain moist after once being soaked full of water. Undoubtedly this method will be found useful by amateurs in many ways.—*Popular Gardening.*

IS WILD PARSNIP REALLY POISONOUS?*

By Frederick B. Power, Madison, Wis.

AFTER reviewing at some length the literature on the supposed poisonous nature of wild parsnip and repeating the facts brought out by himself (*Western Druggist*, March, April and June), disproving that popular theory, the author proceeds as follows:

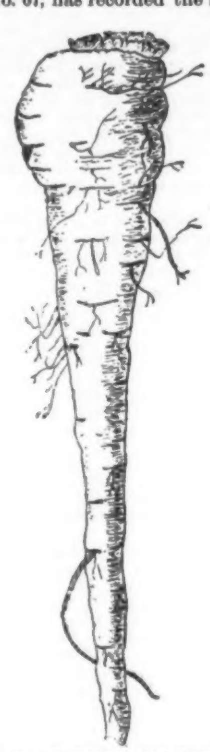
"Du Bois, Pa., April 10, 1891.—Great excitement is caused in this town by the almost wholesale poisoning of five children by eating wild parsnip. Some dozen or more children playing in a vacant lot found the roots and ate them. Two have already died in terrible convulsions."

My inquiries concerning this case were fortunately brought to the notice of one of the attending physicians, Dr. J. W. Avery, of Du Bois, Pa., who kindly extended me the following additional and very interesting information, and also sent me some specimens of the roots. Dr. Avery wrote me concerning the roots supposed to be the wild parsnip, that the most he could find on the subject was contained in an article by Professor George G. Groff, of Bucknell University, Lewisburg, Pa., entitled, "Poisonous Plants of the Farm," published in the Annals of Hygiene, October, 1889, in which Professor Groff speaks briefly but positively. Some specimens of the root brought before the State Sanitary Association of Pennsylvania were examined by some of the members with reference to their appearance, taste and smell, and pronounced to be the wild parsnip, subject, however, to a complete analysis when one of the plants then under cultivation should have flowered. Another botanist who had received a specimen of these roots also reserved his opinion until a flowering plant could be examined. Considering the uncertainty which had thus existed with regard to the identification of these roots, and also the fact that they had been pronounced, although with some reserve, the wild parsnip, it was especially gratifying to be able at once to recognize the specimen sent to me as the Cicuta maculata, L., or the same root that had been the cause of poisoning by the so-called wild parsnip in all the cases hitherto investigated.

With regard to the action of the poison Dr. Avery has given me the following report:

"The eight children poisoned, of whom three died, ate the roots about 11 o'clock A. M., on April 14, and the first symptoms, noticed by the parents about an hour afterward, were vomiting and pain in the epigastrium, soon followed by convulsions, when we (the physicians) were called. Those who died never regained consciousness after the first spasm. The poison having been largely absorbed before physicians were sent for, the treatment was symptomatic. The poison had a powerful inhibitory effect on the centers of respiration and circulation, like the combined action of morphine and atropine; in the case I had, paralyzing the heart center slightly in advance of respiration, though both were almost at a standstill when I first saw the patient, about twenty minutes before death."

Dr. Millspaugh, in his American Medicinal Plants, Fascicle IV., No. 67, has recorded the following obser-

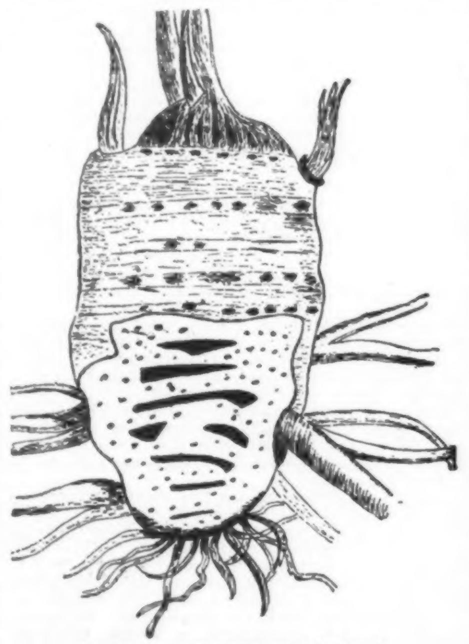


ROOT OF WILD PARSNIP.

(*Pastinaca sativa*, L.) About one-half natural size.

vations concerning the physiological action of the Cicuta maculata:

"Many cases of poisoning from the root of this species have been reported, all showing, by the symptoms, that cicuta produces great hyperæmia of the brain and spinal cord. The following case, reported by letter to Dr. Bigelow by Dr. R. Hazeltine (1818), gives all the symptoms noted by observers in other cases. A boy had eaten of certain tuberous roots gathered in a recently plowed field, supposing them to be artichokes, but which were identified as roots of Cicuta maculata. His first symptom was a pain in the bowels, urging him to an ineffectual attempt at stool, after which he vomited about a teacupful of what appeared to be the recently masticated root, and immediately fell back into convulsions, which lasted off and on continuously until his death. The doctor found him in a profuse



ROOT OF CICUTA VIROSA, L.

(About one-half natural size.) The lower half incised longitudinally, showing cavities.

sweat and convulsive agitations, consisting of tremors, violent contractions and distortions, with alternate and imperfect relaxations of the whole muscular system, astonishing mobility of the eyeballs and eyelids, with widely dilated pupils, stridor dentium, trismus, frothing at the mouth and nose, mixed with blood, and occasionally violent and genuine epilepsy. The convulsive agitations were so powerful and incessant that the doctor could not examine the pulse with sufficient constancy to ascertain its character. At the post-mortem no inflammation was observed, the stomach was fully distended with flatus, and contained about three gills of a muciform and greenish fluid, such as had flowed from the mouth; this mass assumed a dark green color on standing."

With regard to the treatment to be pursued in cases of poisoning by Cicuta maculata and allied plants, Stille and Maisch, National Dispensatory, third edition, p. 453, remark that "the stomach should be emptied at once by emetics and anæsthetics and narcotics used to control the spasm (compare Lene 1857 and Falck 1880)." In a special case that is cited it is also stated that "recovery took place after the internal and external use of stimulants and the hypodermic injection of morphine (Medical News, xl., 524)."

Since it is evident that it is the root of Cicuta maculata, L., which in this country is most frequently mistaken for the true wild parsnip (Pastinaca sativa, L.), and as such mistakes are usually attended with fatal results, it has seemed quite important that some indications should be presented of the chief distinguishing characters of the two roots. The accompanying sketches, therefore, represent a root of the common parsnip in its wild form (after Millspaugh, Amer. Med. Plants) and the tuberous root of the Cicuta virosa, L. (after Nees von Esenbeck, in Plantæ Medicinales). The latter has been selected as showing in a clear and instructive manner the same peculiar structure which characterizes the root of the American plant. It is indicated by Millspaugh that the Cicuta virosa has not a fasciculate root, which distinguishes it from its American congener, Cicuta maculata, but it is believed by the writer that this distinction is not always apparent. These less important differences in the morphological or histological characters of the two species of cicuta could certainly only be established by the comparative examination of a number of specimens at different periods of growth, and must, therefore, be referred to the professional botanist.

The root of the common parsnip, on account of its culinary uses, may be assumed to be so well known as not to require an extended description. It is conical, long and slender, fleshy and succulent, possesses a sweet taste, and when cut or bruised exhales an agreeably aromatic odor.

The Cicuta maculata and Cicuta virosa, in distinction from the parsnip, have an oblong, thick, fleshy root stock or a fascicle of fleshy tubers which send out a number of strong, light colored rootlets in a horizontal direction. The interior of the root is nearly white, and contains one or more cavities, which are formed by absorption of the tissue. These cavities form one of the special and most important characteristics of the cicuta, and, as shown in the drawing, they may easily be seen when a root is cut longitudinally through the center. When cut, it also exudes drops of a yellow, resinous juice, which possesses a strongly aromatic odor, closely resembling that of the parsnip. The taste is at first sweetish, but afterward sharp and acrid.

With regard to the chemical character of the poisonous principle of the cicuta, it may be stated that in the European species (C. virosa) this is referred to as a resinous, indifferent substance, which has received the name of cicutoxin. By distillation with caustic alkalies, basic, volatile bodies have been obtained, but these, unlike coniine, which is afforded by the closely related Conium maculatum, appear to bear no relation to the poisonous action of the plant (compare Husemann, Die Pflanzenstoffe, II. edit., p. 934). It is very desirable that the American species of cicuta (C. maculata) should be subjected to a careful chemical examination, and it is hoped that this can be undertaken at an early date.

* Wisconsin Pharmaceutical Association Proceedings. Condensed from the Pharmaceutische Rundschau.—*Western Druggist.*

SIGNALING TO THE PLANETS.

By Sir Robert S. Ball, LL.D., F.R.S., Astronomer Royal for Ireland.

THE eccentricity which is not infrequently manifested by testators has recently received a somewhat curious illustration. An old French lady, who died at Pau a few weeks ago, seems to have been studying certain astronomical writings with so much enthusiasm that she was stimulated to make a singular bequest. According to M. Flammarion, she has left one hundred thousand francs to be awarded as a prize to that individual, no matter what his nationality, who shall first bring to a successful issue any scheme for opening up communication by signals between this earth and any of the other planets. The donor wished that the fund should be taken charge of by the renowned Institute of France, but she had not unnaturally some misgivings as to whether that illustrious body would charge themselves with so unusual a commission. If they did not accept the trust, then the legacy was to be offered to the Institute of Milan, while in case of their refusal, the money was apparently to take its way across the Atlantic, where it was expected that savants of a more sanguine spirit might be found than those in the Old World.

AN IMPOSSIBLE SCHEME.

I may at once say that it seems utterly impossible for the scheme to be realized; yet still it may be worth while to say a few words on the matter. Indeed, I have received not a few inquiries on the subject. Some of them are from no doubt excellent persons, who appear to think that, by announcing themselves as readers of my little book, "Starland," they become entitled to question me on all astronomical subjects whatever. Suppose, for a moment, that rational beings did exist in some of the other heavenly bodies; it seems difficult to know what conceivable language could be devised by which they could communicate with us, or we could communicate with them. It is not here a question of distance alone, it is the language or symbols to be employed that offer a fundamental difficulty. It is quite conceivable that on some judiciously selected site human endeavor should compile a building or monument sufficiently large to be discerned by dwellers on the moon, if there were any, and if they were provided with telescopes as large as ours. But what hieroglyphics are we to construct which should convey a notion to the mind of a being so totally different from ourselves as must be a denizen on the moon or on any other globe? The hieroglyphics of ancient Egypt are intelligible, more or less, because we have abundant collateral aid. If the ancient scribe depicts a bird, we can at all events understand the immediate object that his

picture represents. But suppose a building representing a colossal bird or a colossal fish were erected on the earth, yet under no circumstances could it be intelligible to a lunarian. His experience on the globe without water will not enable him to recognize the picture of a fish, nor is a bird a familiar conception to one whose only notions are obtained on a globe without air.

A UNIVERSAL SYMBOL.

Some fantastic person, however, long ago suggested that there was one method, and probably only one, by which rational beings, so utterly devoid of all common experience, could, nevertheless, conceivably communicate sympathies of a purely intellectual type. It is a characteristic of mathematical science that it must be the same throughout all space. We cannot conceive a world in which two and two make anything but four, nor can we conceive that the three angles of a triangle drawn in any corner of the universe differ by a fraction of a second from two right angles. If there be intellectual beings elsewhere, and if their faculties have been directed to mathematical pursuits, it is impossible for the arithmetic and the geometry of the most widely separated globes not to have common features. It seems, therefore, conceivable that an intellectual being totally unlike us in every respect, bodily and mental, might yet share with us such conceptions as that the angles of a triangle were equal to two right angles. It has been suggested that if the propositions in Euclid were traced in gigantic figures many leagues in length on the desert of Sahara, and if these were illuminated by rows of brilliant electric lights, they might certainly be visible to inhabitants on the moon. If geometry had been properly cultivated on the moon, the lunarians would comprehend at once the significance of the mighty triangle, and would politely respond by erecting the famous 47th in the crater of Plato, or by decorating the mare serenitatis with the lineaments of the Pons Asinorum. It is clearly something of this kind which stimulated the benevolent lady's offer of a prize of £4,000 for its realization. I do not, however, suppose that the august scientific body to whom it is proposed to intrust the funds will be likely to undertake the charge. So far as the moon is concerned we may look on it as practically certain that there are no inhabitants; and as our next neighbor, Mars, is a hundred times as far away as the moon, it follows that the dimensions of the figures that must be drawn on the earth should be a hundred times as large as those that would suffice to arrest the attention of a supposed lunar inhabitant. In fact, as Flammarion says, an erection on the earth would have to cover about as large an area as Sicily in order to be visible from Mars. It seems, however, to be within the compass of man's power so far to modify the earth on which he dwells that the effect of his operations may be distinctly visible from some of the other heavenly bodies. Professor Langley has pointed out that the influence of man on the continent of America must certainly have affected its appearance when viewed from distant points of space. Along the eastern coast the primeval vegetation has been gradually displaced, and the aspect of the cultivated lands must have given a fringe of a somewhat reddish color to the original green of the continent. Now, indeed, this fringe has extended so widely that the aspect of the continent from whatever points in space it would be visible must be appreciably different from that it bore a few centuries ago. But no one who gives the matter any reasonable attention could expect any results to be realized from this bequest. Even if there were inhabitants on Mars, who knew as much about geometry as we do, we might cover the whole earth with symbols, and yet their eyes, if they have any, might not be fitted to see them.

MARS.

Perhaps the most diligent student of Mars in modern times is Professor Schiaparelli. He has studied the neighboring world in the clear skies of Milan, and he has detected on it many features that had eluded observers who did not possess the same penetration that he is endowed with. Mars has on its globe ruddy regions which seem to be continents of land and dark regions which seem like oceans of water. The poles of Mars are also indicated in a remarkable manner by an accumulation of white material distinctly suggesting the presence of an ice cap at each end of the axis. Mars is also surrounded with an atmosphere less substantial than our own, no doubt, but still of sufficient density to support clouds, though it must be admitted that these clouds have much more tenuity than those on our earth. These features are more or less known to all observers of the planet. It was reserved for the distinguished professor of Milan to detect on the surface a number of curious markings, generally spoken of as "canals." We cannot, with our present knowledge, assert that these have any affinity with what we know as canals on the earth. It is a remarkable circumstance that in some of his drawings the assiduous observer we have mentioned showed that the "canals" in Mars, or many of them at least, were doubled.

THE MARIAN CANALS.

I have alluded to this doubling because the strange idea seems to have been suggested that possibly it may have a connection with the scheme which the bequest of the French lady was intended to further. If we could deliver a message to Mars by the construction of vast diagrams on the globe, is it not conceivable that the inhabitants of Mars may have also conceived a like notion about communicating with us? Indeed, it has been surmised by some imaginative person not only that they may have entertained this idea, but that they may have actually carried it into effect. What we have called "canals" are on this view supposed to be merely the lines of a vast geometrical figure with which the geometers of Mars would appeal to us. They concluded, so our fanciful philosopher says, that we did not see this message, or if we saw it we did not understand it, and accordingly they have emphasized the appeal to our intellectual faculties by duplicating the lines of the diagram in the effort to assure us that they hoped their friendly communication would be understood and invite a response. I confess, however, it seems to me more likely that the "canals," and the doubling of the canals, in so far as the latter is a real phenomenon, may be better explained as indicating an inundation rather than a proposition in Euclid. Nevertheless, he must indeed be rash who presumes to limit the possible discoveries of the future. Who would have thought thirty years ago that we should be ever able to tell the material substances composing the sun? We not only now know these to a large extent, but are even able to tell the elementary bodies present in the most distant objects in space to which our telescopes have been able to penetrate.—*Daily Graphic.*

GUM ARABIC AND ITS MODERN SUBSTITUTES.*

By Dr. S. RIDEAL and W. E. YOULE.

SINCE the closing of the Soudan to commerce consumers have found increasing difficulty in obtaining supplies of gum arabic, and now only small quantities find their way to Europe from the Red Sea littoral and fetch almost prohibitive prices. Consequently the attention of users of mucilaginous and adhesive liquids has been drawn to other sources of natural gums, and an increased stimulus has been given to the manufacturers of dextrin and other gum substitutes. Some notes relating to the appearance and properties of these various natural and artificial substitutes for gum arabic may therefore be of interest.

The various natural substitutes may be divided into two great classes, those which are exudations from the different specimens of acacia, and those which are not.

Of the former class, the principal are the other African gums from Senegal and the Cape and the different Australian wattle gums; while to the latter belong the Indian Ghatti gums.

The investigation of the commercial value of gums from various sources is naturally a problem of some difficulty, and some account of our experience in this direction, on the lines indicated by Liebermann and others, may be of service. Naturally the appearance and color of the gums are of the first importance, and as they are generally bought and sold on an inspection of those physical qualities only, a brief description of the general characteristics of various classes of natural gum arabics is appended.

The finest gum arabic occurs in large white tears possessing a conchoidal fracture, even in size, and readily soluble in water, forming a viscid mucilage perfectly colorless and clear.

Samples of Aden gum arabic which nearly approaches the former in commercial value are in large white or yellowish white tears, mostly perfectly translucent and with the conchoidal fractures and fissures of genuine gum arabic. This gum generally contains a few fragments which are highly colored, and yields with water a viscid clear mucilage, which is quite colorless and leaves no insoluble residue.

Cape gum occurs in irregular masses, not tear-shaped, and of a uniform brownish white color. The fragments are smooth externally and not fissured. The gum is not so freely soluble as the true gum arabics, nor is the solution so viscid.

Indian gums other than Ghattis occur in irregular masses like Cape gum, but of a lighter color, and contain many reddish lumps, which, when broken, show a uniformly flat surface. It is freely soluble in water, but forms a weak solution and is not a good working gum.

Other samples of Oriental gums known in commerce as Eastern gum occur in tear-shaped masses of a whitish brown color with conchoidal fracture. The gum is soluble in water, giving a fairly good mucilage.

Other African gums, of which the gum senegals are the most important, are found in fairly uniform fragments of a whitish brown color and with a conchoidal fracture. They are soluble in water, forming a good mucilage.

All these gums are now met with in commerce and fetch varying prices.

These natural gums, as is well known, consist chiefly of arabic acid in combination with calcium, magnesium, and potassium, and a certain amount of moisture. A portion of the arabic acid, or arabin, may exist in the gum as metarabin, an insoluble modification of metarabin. Such gums leave an insoluble residue, which swells up in water but does not dissolve.

As no process has been proposed for the accurate estimation of arabin directly, and as such a process, if available, could probably not give an index to the commercial quality of the gum, the analyst has to be guided by other considerations in the assay of gum.

From determinations of the ash of the sample, its viscosity in solution, which is a measure of its mucilaginous and adhesive power, and the amount of water which the natural gum contains, a fair idea of its commercial value may be ascertained.

The ash of a genuine natural gum should be white in color and consist chiefly of a mixture of calcium, magnesium, and potassium carbonates, with a trace of sodium chloride.

The following table summarizes the results obtained from typical samples from different localities:

No. of Sample.	Ash.	NaCl.	K_2CO_3	$CaCO_3$	$MgCO_3$	Total.
1. Aden......	3·29	0·29	17·2	53·90	29·48	100·86
2. Cape......	3·05	1·14	15·40	57·90	28·80	103·33
3. Indian....	2·003	0·37	12·6	58·50	29·82	101·29
4. Eastern...	2·93	0·24	26·8	43·50	..	..
5. (?)........	3·19	0·21	18·01	44·70	34·30	97·22
6. Senegal...	3·03	0·14	21·5	54·90	15·96	92·50
7. (?)........	2·40	0·14	24·9	53·10	..	..
6. Senegal...	3·38	0·14	17·14	50·32	..	..
9. (?)........	3·18	2·00	13·65	50·39	..	..
10. (?).......	3·06	0·21	15·8	54·50	30·07	100·58
11. (?).......	2·76	0·24	17·10	49·04	29·94	96·32
12. Finest arabic	3·01	0·94	24·2	57·25	..	..
13. Good "	3·15	2·30	29·9	46·23	..	..
14. Cape......	2·61	2·29	42·2	52·73	..	..

* A paper read before the Society of Chemical Industry, London, 1891. From the Journal.

It is commonly stated that gum arabic yields from 2 to 3 per cent. of ash, but we have not been able to find any record of analyses of the mineral constituents.

We tried most of the established tests used by pharmacists for the detection of gum arabic on all the gums which we have had an opportunity of examining. The aqueous solution of a natural gum invariably gives a white precipitate with alcohol, with ammonium oxalate solution, and with subacetate of lead. They do not appreciably reduce Fehling's solution when boiled with it, most samples being without any reaction; some however gave a slight reduction. Iodine in potassium iodide gave no reddish or blue color. As dextrin and starch are almost invariably present in the artificial gums, this last reaction is of great value in the preliminary examination of a gum. Hager's reagent, which consists of a saturated solution of potassium ferricyanide, with an equal volume of dialyzed iron, and some dilute hydrochloric acid, was also tried; but its only value appears to be in discriminating dextrin from natural gums. With the former it strikes a deep blue color on allowing the mixture to stand. The reaction of course depends upon the reducing power of the dextrin producing Turnbull's blue, no body having such a property being present in natural gums. The test is therefore of no use in discriminating between natural gums. Copper acetate and a few drops of acetic acid when boiled with the gum solutions gives no reduction, showing the absence of glucoses. Liebermann recommends the use of dilute potash and copper sulphate solution to effect the assay of gum arabic and gum senegal whether adulterated or not with dextrin. He adds first the alkali and then the copper sulphate solution to the cold aqueous solution of the gum under examination, filters off the flocculent blue precipitate of copper arabinate after warming, and boils the filtrate, when dextrin, if present, causes a reduction of the copper sulphate. The precipitate on the filter is washed with warm water, dissolved in dilute hydrochloric acid, and the free arabic acid (pure gum) precipitated by the addition of a large excess of alcohol. From the reaction of the gum acid thus obtained, he decided whether it has been derived from a true gum arabic or from gum senegal. It is evident that the distinguishing tests which he proposes depend for their success on the presence of accidental impurities, and not on any difference in the behavior of the arabic acid, which is the chief constituent of both gums. The test which Liebermann most relies on is the formation of a color on boiling with dilute potash. He remarks that gum arabics give an amber yellow color, while senegal is scarcely affected. Our own experience does not bear out these results. We determined the potash absorptions of several samples of gum and also noticed the color given by each:

Gum.	Weight of KOH absorbed.	Colour produced.
1. Aden gum arabic.........	7·87	Yellow.
2. Cape gum................	7·47	Yellow.
3. Indian gum..............	6·82	Green
4. Eastern gum.............	9·04	Yellow.
5. Source unknown..........	5·48	Yellow.
6. African Senegal.........	2·48	Yellow.
7. Source unknown..........	2·39	Yellow.
8. Source unknown..........	6·46	Yellow.
11. Source unknown.........	2·08	Yellow.
12. Finest gum arabic......	2·57	Green.
13. Good gum arabic........	1·92	Green.
14. Cape gum...............	4·87	Yellowish brown.

From these results one would infer that the color produced on boiling with potash is no indication of the source of a gum, as sample No. 1, a good gum arabic of ascertained purity, gives a yellow color, while samples 12 and 13, also genuine gum arabics, give a green color when similarly treated. On the other hand, the majority of samples of gum from very different sources give a similar yellow color on boiling with the KOH. It is possible that the tint produced is due to a slight decomposition of the arabin by the action of heat and potash. As will be noted further on, Ghatti gums from India react strikingly with potash, producing a characteristic pink color. On the whole, so far as our experience goes, the methods of determining the source of any exudation from the acacia, chemically, are very unsatisfactory, and the chemist, like the gum consumer, has to rely chiefly upon the physical appearance and properties of the gum.

The determination of the moisture present in natural gums has established the fact that the loss on heating to 100° C. varies from about 10 per cent. to 15 per cent. of the total weight, but no attempt can be made apparently to classify gums according to the percentage of water they contain. Samples of gum of good quality lose more water often than inferior specimens, while the time of year in which the gum is collected has a considerable influence on the result. A marked difference is shown in the different losses of moisture undergone by dextrins and other artificial gums compared with natural gums. The dextrins at 100° C. appear not to lose more than 4 or 5 per cent., while no gum arabics which we have examined give such a low percentage. Liebermann states that the losses undergone by gums arabic and senegal respectively are 13·89 per cent. and 14·56 per cent. at 108° C. On the other hand, he found that the dried senegal gum absorbed more water exposed to a warm damp atmosphere for 24 hours than the dry gum arabic, the respective increases being 6·15 per cent. and 2·24 per cent. It is of course obvious that the more water is expelled from a gum by heat, the more it will be prone to take up when re-exposed to moist air. All the samples of gum with which we have had to deal have universally taken up more water when exposed upon glass slides over water in a bell jar. If the conditions are changed, however, they will lose this excess of moisture with a rapidity depending upon the nature of the gum. By experi-

ments of this sort conducted in a specially constructed apparatus, it is possible to obtain a fairly accurate idea of the behavior of the gums used in envelope gumming, etc., when exposed to a tropical climate. This is a point of some practical importance, as it has been found that gums which work very well in the temperate zone are altogether useless when used for goods intended for India, etc., as in such climates a hygroscopic gum is valueless for stamps, envelopes, etc.

The determination of the viscosity of a gum solution is of great importance in forming an estimate of its commercial value. The usual method of doing this is to note the time taken by 50 c. c. of a 10 per cent. solution to run out from a burette fitted with a fine jet, as compared with the time taken by water under the same conditions. The longer the time the more viscous the gum; but it is evident that the numbers obtained are not strictly proportional to the true viscosity, and at the best only relative numbers are obtainable. The qualitative results obtained in this way are of little value in fixing the true viscosity of any gum solution. The burette method informs the operator of the bare fact that one gum is better than another, but the results do not carry any quantitative significance, and he is left quite in the dark as to the extent of the superiority of the better gum. The figures obtained also vary so much with slight differences of temperature that very serious errors may arise if the operator, working on two different days, does not use for the purposes of comparison all the standard gums he had previously employed. A rapid and simple process for estimating viscosity which shall be free from the more serious errors of the burette method is evidently a desideratum, and we have found no difficulty in working with an apparatus which gives absolute results, and suggest that some uniform system might be adopted by those engaged in these determinations.

The adhesiveness of a gum is of course of great importance; and although we have made attempts to adapt the methods used for testing the strength of paper, glue, belting, etc., for obtaining numerical values for this property, we find that a qualitative trial of the gum on paper gives practically all the information that is needed.

We found that with the above data a very fair estimate of the commercial value of a gum for any particular class of work may be formed.

The second class of natural gums now in the market are those of which Ghatti gum may be taken as a type. These gums apparently contain much more metarabin than the acacia gums, and consequently are not so readily nor so completely soluble in water. The fact that a considerable residue was left on treating the gums with water at first misled buyers, as the superior viscosity of the soluble portion was not immediately recognized. At the present time a considerable quantity of these gums are employed, partly as adulterants for the gums which are completely soluble in water, and partly by those manufacturers who find that the mucilages obtained from them answer their special purpose.

Ghatti gum generally appears in rough, irregular fragments, of a brownish color and somewhat dirty, containing fragments of bark, straw, etc. It is much harder than gum arabic and not so brittle, so that it is a matter of some difficulty to reduce it to fine powder in a porcelain mortar. Most samples contain a considerable proportion of vermicelli-shaped tears of a yellowish white color, which are almost insoluble in water and apparently consist of nearly pure metarabin.

The chemical examination of these gums is conducted on practically the same lines as for a gum arabic. The ash varies from 2 to 3 per cent., and consists of the same constituents as a gum arabic ash, viz., calcium, magnesium, and potassium carbonates, and sodium chloride, with the addition of alumina and a little calcium phosphate.

The loss of water on drying at 100° C. is not so high as for a gum arabic, being from 4 per cent. up to 7 per cent. The general hygrometric quality of this class of gums is good, and they are on the whole well suited for tropical work.

The viscosity of Ghatti samples as compared with those of gum arabics is the most remarkable property of these gums. On first commencing work upon them, we found it necessary to employ a viscosity solution weaker than 10 per cent., as solutions of that strength would scarcely flow and were tedious to manipulate. We have therefore since employed universally 5 per cent. solutions in the determinations of their viscosity. A comparison of the figures obtained with them and with good gum arabics in the same burette shows the remarkable viscosity of the former:

Sample.	Strength.	Burette time in seconds.
	Per Cent.	
1. Gum arabic	10	99
2. Gum arabic	10	79
1. Ghatti	10	817
Ditto	5	88·7
2. Ghatti	5	117
Ditto	10	147

Thus the Ghatti No. 1 is distinctly superior to gum arabic No. 1, which is the best Aden gum; while the other sample is considerably better than even Ghatti No. 1. As a matter of fact none of the specimens of Ghatti gum which we have since examined have fallen below No. 1 in viscosity, so it is evident that this superior viscosity is one of the characteristics of this gum.

In two or three of the samples we have roughly estimated the amount of insoluble matter left on making the viscosity solutions, and have found it varies from 5 per cent. to 15 per cent. The gums are certainly markedly less soluble than the acacia gums, but the prolonged action of water appears to slowly dissolve the metarabin, probably by converting it first into arabin. The action of boiling water is much more efficacious, and far better solutions are obtained from gums containing much metarabin by boiling the powdered gum with water. A cold water solution, however, has other advantages for some kinds of work.

Reference has already been made to the action of potash upon Ghatti gums. As a class they take up less potash per unit weight of gum than the gum arabics, although they differ considerably.

Sample.	Amount of KOH absorbed.	Colours of Liquid.
	Per Cent.	
1. Ghatti gum	3·99	Pink.
2. Ghatti gum	3·97	Pink.
3. Ghatti gum	0·23	Pink.
4. Ghatti gum	3·68	Pink.
5. Ghatti gum	0·225	Pink.

The pink color of the solutions after burning with KOH seems characteristic of the Ghatti gums, none of the others we have examined giving such a color reaction.

Among the gums introduced into the market there are others which in physical appearance, etc., are markedly different to the rest. Among these the most important are the Amrad and wattle gums.

Amrad gum comes from the highlands of Abyssinia, and is an exudation from the *Acacia abaica*. It occurs in commerce in dark brown or yellow tears with a smooth surface and fairly regular in size. It possesses a remarkable aromatic odor. The gum is soluble in water, leaving no residue, and giving a moderately viscid solution equal to the second class gum arabics. The ash is about 2·34 per cent., perfectly white and of similar composition to the ash of the other gums, being free from the alumina and phosphate which appear characteristic of the Ghatti gums. Its price is prohibitive at present of its superseding the second rate gum arabics and the Ghatti gums for commercial purposes.

A better prospect appears to be open for the Australian gums, which under the generic name of wattle gum have been of late years introduced into the English market. All these gums which are classed together as wattle are exudations from numerous species of acacia. They are apparently divisible into two classes, the coast gums, which contain much metarabin and swell up in water, and the gums from the interior, which are freely soluble. In general appearance wattle somewhat resembles the commoner kinds of Cape gum, being usually of a dark brown or amber color with a glassy even fracture, and dirty in appearance, owing to its being admixed with bark, etc. The higher grades are probably equal to the second class of gum arabics, but many samples do not attain this excellence. The ash is somewhat variable but usually lies between 2 and 4 per cent., not greatly exceeding the latter. The moisture is a trifle higher than for gum arabics, being 16 to 17 per cent. The gums yield a tolerably viscid mucilage which is said to be very adhesive. Unfortunately the best samples of this class of gum seem hard to get hold of, and are not apparently yielded in large quantities by the gum-bearing trees.

At present the gums are not exported in very large quantities, but there is certainly an opening for them if prices do not rule too high.

An exhaustive examination of the wattle gum-bearing trees and of the composition of the exuded gums has been made by J. Maiden, who divides them into three groups according to their solubilities in water, which, of course, depends upon the varying amounts of metarabin present (v. Maiden, Pharm. J. xx. 869, 980) [111].

Of the bodies which are artificially prepared and used as gum substitutes, the most important is dextrin. This has a widely extended use for cheap gumming work, and being easily "reduced," is in great favor. The commercial dextrins used for this work always contain more or less unaltered starch. They are therefore "reduced" with hot water or steam, and the starch thus gelatinized materially affects the viscosity of the solution. Up to a certain limit, therefore, the presence of starch in a dextrin increases its commercial value for this class of work.

To distinguish between a dextrin and a natural gum is no difficult matter. Besides the iodine test there is the reducing action which commercial dextrins have upon Fehling's solution, and the absence of a precipitate with alcohol in dilute solutions.

Dextrins are readily distinguished from gums quantitatively by the low ash which they yield on incineration. Among the samples examined by us none exceeded 0·3 per cent. mineral matter, and some were much lower, just over 0·1 per cent. The ash appears to be of similar qualitative composition to that of natural gums, though alkaline carbonates are conspicuous by their absence; but the amount of chloride is considerably greater, and some samples contain phosphates and alumina.

The amount of water which dextrins yield on drying at 100° C. is smaller than for natural gums, but on raising the temperature to 110° C. they lose much more, as a general rule, as the following results show:

Dextrin.	Loss Moisture at 100° C.	Loss at 110° C.
Sample 1	3·57	10·12
Sample 2	4·10	10·4

It is not advisable to subject gums to a temperature of 110° C. as they show a tendency to char and become slightly discolored, so we have no reliable data as to the loss of water experienced by them at this temperature.

The viscosity of dextrins ordinarily is about equal to that of third rate gum arabics.

The behavior of dextrins with potash is characteristic. They take up a large percentage of KOH and yield a deep red solution quite different to that given by gums arabic or Ghatti. Comparison with the previous figures will illustrate this:

Sample.	Amount KOH taken up.	Colour of Solution.
	Per Cent.	
No. 1	25·4	Dark red.
No. 2	19·7	Almost black.

Both dextrin and gums give a precipitate on the addition of lead subacetate (Goulard). The filtrate is opalescent or milky with the gums, but is clear with a dextrin. This test has been recommended by Schloster for the detection of adulterants in gum, but while the iodine and Fehling tests are available, it seems somewhat superfluous and less easy of execution.

Of late years several varieties of dextrin made up somewhat to resemble gums have been put upon the market. To such belong Stead's patent dextrin, which is made by filtering ordinary dextrin solution through animal charcoal and evaporating with a little nitric acid, when a transparent mass is obtained, which is said to be free from any offensive taste. The adhesiveness is also said to be unimpaired by this treatment. A "starch" gum has also been prepared by an Alsatian firm by the action of sulphurous acid upon starch paste under pressure at a high temperature. The resulting liquid is evaporated in vacuo. This gum gives a blue coloration with iodine, showing presence of unaltered starch, and is used in confectionery.

According to the patent specification the dextrin is free from odor and taste when the starch paste is boiled with half a per cent. of sulphurous acid until a trace of glucose can be detected. The resulting product is neutralized and filtered through animal charcoal, and then boiled down. The dextrin obtained is brilliantly white in color. Schumann's non-fermentable cement is probably the same compound. This is made by mixing starch with water to a thin cream, adding acid and allowing to stand for 24 hours. The residual starch is washed free from acid and heated in a digester to 160° C. or 170° C., which converts all the starch into dextrin. The product is heated with a solution of albumen filtered through animal charcoal and evaporated to dryness. The resulting artificial gum is devoid of taste and smell, and is similar in appearance to a natural gum.

Of a similar nature to dextrin, and, from their consisting largely of it, almost identical with the former in chemical reactions, are the various artificial "gums." Numerous patents have been taken out for different methods of preparing these, but generally speaking they fall into three great classes, viz.:

A.—Those containing only dextrin and gum.

B.—Those containing dextrin or other carbohydrates with nitrogenous bodies.

C.—Those consisting entirely of nitrogenous bodies, as liquid glue, fish glue, etc.

To the first class belong the patents of Rossi and Hellfrisch for preparing gum from starch by the action of sulphurous acid under pressure. The product consists of "gommaline," dextrin and a trace of glucose, and is stated to be clear, non-hygroscopic, and to have an adhesive power nearly equal to gum arabic. This "gommaline," although a gummy matter, is not true gum. Little is known concerning it, but probably it is only a modified form of dextrin. If so, the true place of this gum substitute would be under the real dextrins. An artificial gum was brought on the American market some two years ago, made by boiling down dextrin solution with gum arabic in vacuo. Several brands of "gum" made by this or a similar process are on the English market at the present time, and are used for many classes of work. Some consumers complain of them changing rapidly in consistency, especially in winter, and it has been recommended to boil the solid gums with 1½ times their weight of caustic lime, when it is stated the solutions retain their strength for weeks.

The general chemical characteristics of the first class of gum substitutes are low ash, indicating a high percentage of dextrin; loss of water on drying at 100° C., rather less than natural gum arabics, being about 10 per cent.; and moderate viscosity. None of the samples which have come under our notice have been above third rate gum arabics in this respect.

Among the second class of gum substitutes or mixtures of dextrin with nitrogenous compounds we may refer to the compound "arabol," which has been introduced into the market by an American firm. It contains dextrin admixed with some nitrogenous body, such as albumen or casein, and is put on the market as a brown sticky mass containing upward of 35 per cent. moisture and yielding a light colored solution which is not very viscid, about equal to that of a good dextrin. When boiled with aqueous KOH it assumes an almost black color and absorbs 40·6 per cent. calculated on the dry material, pointing to a high percentage of dextrin as we have previously observed. The "Arabol" Company claim that the product works well both for envelope and label gumming and lithographers' work, also for various general purposes as a substitute for gum arabic. It is open to the objection that it is very hygroscopic, although we are informed that this objection to its use has been remedied by an improved process of manufacture.

Gum substitutes of the second class will give low ashes on incineration, unless, like Strasser's patent, borax or some other mineral preservative has been added. The ash of "arabol" we found to be 0·58 per cent. It was brown in color and contained notable quantities of ferric oxide, alumina and calcium phosphate associated with the usual constituents of a gum or dextrin ash, viz., calcium carbonate and sodium chloride, but no alkaline carbonates. This was the first body of this class in which we found ferric oxide in the ash. It also contains sulphate, which we had not previously found in dextrins or gums.

The viscosity of such substitutes must naturally vary very greatly, but none of those which have come under our notice were equal to second class gum arabics, even allowing for the higher percentage of moisture which they contained. It may be noticed, moreover, that they are easily affected by climate, more readily than dextrins as a class, so that it would seem that the addition of gelatin, etc., makes the body more hygroscopic. On the other hand, when dry they exhibit a tendency to peel off the surface over which they are spread.

The third class of gum substitutes includes bodies which are made from animal matter.

To the first division belong the so-called "liquid gums" made by heating glue with water, borax and carbonate of soda for some hours. When this is properly done the product remains permanently liquid on cooling, and may be boiled down to any required degree of strength. Other kinds of "liquid gum" are made by heating glue with alum.

The second division includes the gelatinous substances obtained from fish bones and cartilage, known under the name of fish glue. It is a light brown viscous liquid with an offensive odor and an acrid taste. It forms a sticky mucilage when diluted with water, and as met with in commerce already contains about half its weight of water, and such a liquid is, weight for weight, only about equal to a dextrin in viscosity. If the comparison were made on the dried fish glue, of course it would stand much higher, equaling some of the second class gum arabics.

The ash of these fish glues is comparatively high, being usually about 4 per cent. on the body dried at 100° C. It is usually white in color, and contains, besides calcium and potassium carbonates and soda chloride, some 5 to 10 per cent. of tricalcium phosphate.

On boiling with potash, fish glue assumes a greenish yellow color and absorbs a comparatively small amount. A sample containing 45 per cent. of water gave a potash absorption of 9 per cent.

Liquid gums of this class are easily recognized by boiling with Fehling's solution, when they assume a violet color, and by the tannic acid reaction, the presence of nitrogen and the absence of the dextrin reaction with iodine solution discloses their identity.

The unpleasant odor and taste of fish glue is one of the objections to its use. Otherwise from a commercial point of view it is superior to many dextrins, but it is, like "arabol," somewhat weak in hygrometric character. It, however, rapidly becomes dry and crisp again.

We have made several attempts to remove the unpleasant odor from fish glue, and are still working in this direction. We have found that when the glue is heated on the water bath for several hours with borax, caustic soda, sodium carbonate, and lime, although they have a temporary deodorizing effect, do not permanently destroy its odor. A better method consists in boiling the fish glue with 1 per cent. sodium phosphate and adding 0·025 per cent. of saccharin. A fish glue thus treated loses its unpleasant odor almost entirely and also its acrid taste.

In reviewing the literature on the analysis and properties of natural gums, we were struck with the small amount of definite data arrived at from an examination of representative samples, and have thought that the following tabular statement showing the sort of results obtained from the analysis of the ashes of other gums than those given on p. 13107, and the difference between them and artificial gums, would be of interest:

combined determined, Ghatti gums give a higher percentage of BaO absorbed than they should from the ratio K_2O : BaO. The following figures illustrate this, viz.:

Ghatti Gum.	Amount KOH absorbed reckoned to K_2O.	Theoretical BaO absorption from ratio K_2O : BaO	Actual BaO absorption.
Sample 1....	3·999	6·49	7·00
Sample 2....	3·089	5·09	7·35
Sample 3....	3·970	6·47	6·92
Sample 4....	0·230	0·374	0·40
Sample 5....	0·225	0·366	0·39

When alcoholic-semi normal potash is substituted for the aqueous potash both gum Ghatti and arabic give lower results, *e. g.*:

Sample.	K_2O absorbed Aqueous.	K_2O absorbed Alcoholic.
Gum arabic.......	6·28	1·15
Ghatti gum.......	3·94	2·84

In both cases a gummy residue was left undissolved in the flask, while aqueous potash causes in every case an immediate solution of the gum on warming. It will be observed that the ratio of the alcoholic K_2O absorption to the aqueous is much greater in the case of gum arabic than in that of Ghatti. This may furnish another means of identifying Ghatti gum, but our experiments on this point require extending. The fact that the constituents of Ghatti are not nearly so insoluble in alcohol as those of gum arabic is also shown by the respective yield of precipitates with alcohol.

In order to compare gum tragacanth, which, although it has no adhesive value, makes a good mucilage, with the Ghattis, we made a determination of the ash, potash absorption, etc., of a good sample of this gum. The detailed analysis of the ash is given in the table below. The potash absorption gave 12·6 per cent. K_2O absorbed or 15·04 per cent. KOH. The resulting liquid was bright yellow. Mr. R. Williams obtained, using alcoholic potash for two samples of tragacanth, the numbers 11·05 and 11·98 for the KOH absorption.

We have already pointed out that for the commercial valuation of the viscosity of gums the burette method is liable to give misleading results. It is true that the emptying times afford a measure of the viscosity of the gums, and were it possible or convenient to make up fresh solutions of various samples of gums, and take their viscosity by this method together with that of a newly received sample, the figures obtained would fix the place of the new gum with regard to any one of the old samples. But in practice it is certainly not convenient, nor even practicable, to make up viscosity solutions of 20 or 30 samples of gum, and we have found by experience that the *numbers* given by the burette method are useless by themselves, and give no indication of the value of the gum, for when it is necessary to determine the true ratio between the viscosity of various gums some other method must be employed. We have found convenient for this purpose a modified form of the apparatus described by Slotte. It consisted of a double bulbed instrument, in which the two bulbs are connected by capillary tubing. The bulbs are practically of the same capacity, and one is fitted with tubes so that the solution undergoing trial can be sucked over, and afterward when the first bulb is filled returned to the second by means of a tube for a second test. The capillary tube is continued upward into the first bulb for half its diameter, so that no correction is required for the effect due to gravity upon the liquid in the second bulb.

Sample.	Ash.	$CaCO_3$	$MgCO_3$	K_2CO.	NaCl.	$Ca_3P_2O_8 + Al_2O_3 + SiO_2$	Total.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Amrad gum.........	2·24	67·20	16·62	7·39	0·14	4·86	96·21
Ghatti gum.........	2·45	83·50	8·40	7·80	0·25	33·80	103·75
Ghatti gum.........	3·11	55·01	10·10	7·10	0·31	23·10	95·62
Ghatti gum.........	2·24	60·20	10·33	9·29	0·30	30·50	101·62
Dextrin..............	0·12	6·45	..	..	15·10	73·40	94·98
Gum tragacanth...	2·803	76·30	8·89	11·90	1·14	4·74	101·07
Australian..........	2·09	20·80	0·45	3·21	1·91	65·95	92·32
Brazilian	1·39	11·80	0·45	17·74	0·468	69·14	99·6
Brazilian	2·38	15·50	10·40	17·12	0·213	53·50	96·78

The above are only intended to give a rough idea of the relative arrangement of the constituents in gums of known origin. They do not pretend to be strictly accurate, in fact the small quantities, never exceeding 0·2 grm., of ash operated upon forbid this. No provision was made for soluble silica, and the estimation of this in some of the gums would probably bring the totals nearer 100 per cent. The amount of potassium carbonate varies very much in the natural gums, as reference to the table will show. Dextrins contain generally no potassium carbonate in their ash, while the gum substitutes of the first class increase in potassium carbonate according as more or less true gum is mixed with the dextrin. Among the members of the second group of gum substitutes we found no soluble alkali in "arabol," while fish glues are rich in potassium carbonate. It will be seen, therefore, that the presence of potassium carbonate in the ash of a gum or mucilaginous body generally denotes the presence of natural gum or gelatin, while its entire absence indicates the body to be largely composed of dextrin.

The potash absorptions which we have already alluded to were obtained with semi-normal aqueous potash and confirm those obtained by Rowland Williams, who used alcoholic potash. He found for three samples of gum arabic figures ranging between 5·5 and 9 per cent. of potash absorption, while a single sample of senegal absorbed 10·42 per cent. It will be seen by comparing these figures by those obtained by us (page 13107), that they fall fairly within the limits which we found with a much larger number of samples. The most marked discrepancy is in the gum senegal, but if an Aden gum arabic, like our first sample, varies as much from another genuine gum arabic as do the values obtained for each, viz., 7·87 and 2·57, it is quite possible for two samples of senegal gum to vary at least as much. The different colors produced by the action of potash on the various natural gums and on dextrin have already been noted.

If the ash falls below 1 per cent., and the potash absorption rises much over 10 per cent., the presence of dextrin in the sample may be regarded as certain. Ghatti gums, as was seen, give uniformly low results when boiled with potash, no sample absorbing as much as 4 per cent., while some are below 1 per cent. It is noteworthy, however, that when shaken with saturated baryta water and the resultant liquid precipitated with alcohol and filtered, and the amount of baryta left un-

The apparatus employed by us is shown in the accompanying diagram. The only essential difference is that it has only one bulb, the gum solution being sucked up from a bottle.

To take a viscosity determination by means of this apparatus, certain data must be known, as from them is calculated the "constant" k of the instrument.

This "constant" is equal to the value of $\frac{\pi r^4}{8 l q}$ where q is the volume of the bulb in cubic centimeters, l the length of the capillary tube in centimeters, and r the radius of the capillary in centimeters. The height h from the center of the bulb to the extremity of the capillary is also required.

From the viscous nature of most 10 per cent. natural gum solutions, we generally use artificial pressure to raise the solution in the bulb, but it is quite possible theoretically to determine the viscosity of a gum by simply allowing it to flow out from the bulb and noting the time taken in seconds; and as this is the simplest case for the calculation of the result, we will consider it first. The gum solution is placed in the bottle, and the gum, by pressure or otherwise, is sucked up into the bulbs till the upper safety bulb is full. The solution is then allowed to run out from the bulbs back to the bottle under the influence of gravity alone, the time taken to flow from the upper to the lower mark between the bulbs being noted in seconds. Representing the absolute viscosity by η, we have:

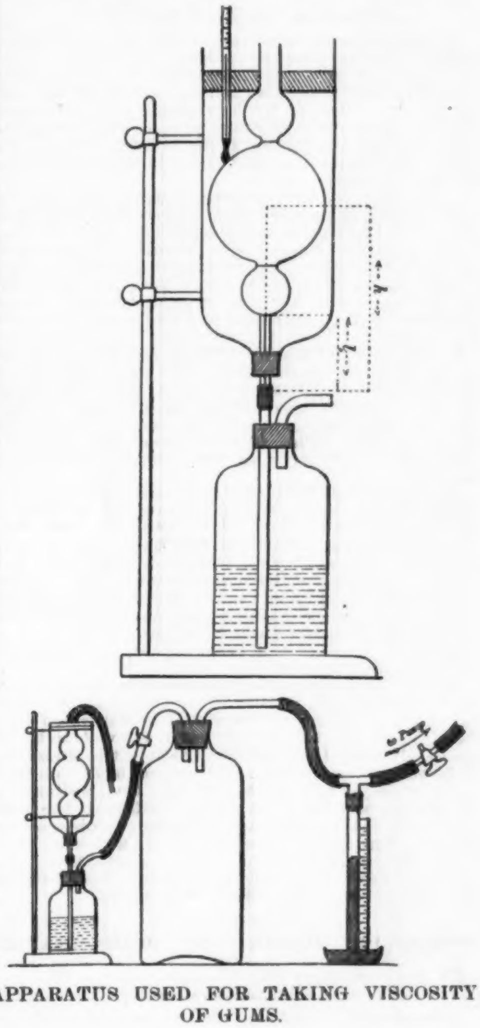
$$\eta = k g h d t$$

in which k is the constant for the instrument obtained as above, g the effect of gravity in C. G. S. units, d the density of the gum (average density of 15 solutions of 10 per cent. strength 1·024) and h the mean height previously taken. The value for η as thus obtained is usually a small decimal varying from 0·2 to 0·03 per cent., according as the sample is a good natural gum, or a dextrin or other gum substitute. If the value of the η of distilled water be taken previously to the viscosity, it will afford a check on the calculation on the k of the instrument, as the absolute viscosity of water at various temperatures has been accurately determined by Poiseuille and others.

The method of allowing the gum to flow out by itself from the instrument is tedious with good samples of natural gum if 10 per cent. solutions be adhered to; but equally good results are obtained with much greater rapidity by sucking up and forcing out the gum under diminished pressure. The only disadvantage is a slightly more complicated calculation. When working under diminished pressure, the following expression—

$$\eta = K g \left(\frac{t_f + t_e}{2} H D + \frac{t_f - t_e}{2} h d \right)$$

gives the value of the viscosity where t_f is the time of filling, t_e the emptying time, and H the height of mercury pressure in centimeters, and D the density of mercury (13·6).



APPARATUS USED FOR TAKING VISCOSITY OF GUMS.

The equation in the above form is deduced from the general one—

$$\eta = K t \left[\tfrac{1}{4} d (V_e^2 + V_f^2) - (P - p) \right]$$

in which t is the mean time, and V_e, V_f the velocities corresponding to the times t_e and t_f. $(P - p)$ is the effect of difference of pressure expressed in dynes, and so is equivalent to H D g. Our working equation is obtained from the general one by neglecting $\frac{1}{4} d (V_e^2 + V_f^2)$, as this expression represents the kinetic energy left in the liquid after falling the height h, and this, in cases where the time is large, is very small and may be disregarded. On the other hand, if the rate of flow be rapid, a correction made first by Slotte comes into play, which is a correction for the kinetic energy in the liquid which increases with the velocity, and in which allowance is made for the liquid at different portions not moving with the same velocity. The equation is expressed thus—

$$\eta = K \frac{t_e + t_f}{2} (P - p) - \left(\frac{d Q}{2 \frac{1}{3}{}^2 \pi^2} \right) \frac{1}{t^2}$$

in which the first portion is a compressed form of the general equation above, while

$$\left(\frac{d Q}{2 \frac{1}{3}{}^2 \pi_e} \right) \frac{1}{t^2}$$

is the new correction. It depends, as will be seen, on the size of the bulb and the length of the capillary, which remain constant, for the same instrument, and on the emptying time for the particular experiment. It

will be seen, therefore, that as the emptying time increases so does this correction diminish, and, in fact, for times over three minutes may be disregarded. The best way of using this correction is to find once for all the value of

$$\left(\frac{d\,Q}{2^{1/2}\,\pi^{s}}\right)$$

for the particular instrument in use, and call this K_s. It is about 0 22 for an instrument of the dimensions described. Then, Slotte's correction becomes $\frac{K_s}{t^s}$, and a table can be readily made of the values of the correction from 15 seconds up to about 150 seconds, which will be the highest emptying time ever likely to be obtained working with pressure. This correction is made on the uncorrected absolute viscosity which is previously worked out from the equation by aid of logarithms and expressed as a decimal. The figures obtained thus can be transformed to a shape more suitable for practice by dividing the absolute viscosity of the gum solution by the absolute viscosity of water obtained in the same instrument at the same temperature and multiplied by 100, *i. e.*

$$\frac{\eta \text{ of gum} \times 100}{\eta \text{ of water}} = Z$$

which is more convenient to use in comparing various solutions.

(To be continued.)

PREPARATION OF SIRUPS.

IN discussing at some length the various pharmacopœial methods for the preparation of sirups, W. Bernhardt, in a recent contribution to the Deutsch-Amerikanische Apotheker Zeitung, comes to the conclusion that with but very few exceptions—where heat would deleteriously affect the product—dissolving the sugar by heat and raising to the boiling point is the best. To insure the best results, the author lays down these rules:

1. Employ only the best grade of cane sugar; for the lower grades of sugar contain appreciable amounts of glucose which inclines to fermentation. Follow closely the quantities directed in a formula. Concentrated saccharine solutions resist fermentation in a much higher degree than more dilute ones; on the other hand, there will be loss from crystallization if sirups, prepared by heat, are stored in a cool room, as is sometimes done.

2. Use none but absolutely clear vegetable extracts, seeing to it that after ebullition the sirup also be perfectly bright: the latter object may be accomplished by the customary aids, such as the addition of albumen or pure filtering paper pulp before bringing the sirup to a boil. This does not apply, of course, to naturally turbid sirup, as, for instance, sirup of almonds.

The author sets forth that even with most aromatic sirups the loss of volatile constituents can be but trifling if the process of boiling be properly conducted; the inversion of saccharose may be left out of consideration, especially when fruit acids are absent—provided the solution of the sugar be completed at a low temperature, and then rapidly raised to the boiling point; albuminous substances are frequently extracted from the raw material which boiling will remove; all fermentative germs and fungus spores are effectually destroyed by the heat.

Finally, to insure perfect preservation, sirups should be filled into small vials (of from two to eight ounces capacity, according to individual needs) which have been placed into boiling hot water, the vials to be immediately corked and sealed. [As an extra precaution it is well to lay the filled and corked bottles on their sides, while yet hot, and to maintain that position. A French proposition is to fill the bottles to the brim and, while the contents are still warm, to place on top so as to come in contact with the sirup a circular piece of filtering paper. A firm cover of crystallized sugar is thus obtained, well calculated to exclude all extraneous matter.—EDITOR.]—*Western Druggist.*

WILLESDEN PAPER FOR PHOTOGRAPHIC USE.

By BAYNHAM JONES.

I WAS much interested in the exhibition at last year's "Inventories" of the capabilities of the Willesden paper, which comprised, *inter alia*, life boats and other vessels, which require not only to be waterproof but, at the same time, to combine great strength. I was, however, surprised and disappointed at not finding photographic dishes, funnels, and other photographic requisites in the stall. I concluded that these matters had been overlooked by the manufacturers, and that I should in the course of a few weeks find all the photographic stores filled with them.

Some thirty years since I visited Messrs. Jennings & Betteridges' papier-mache manufactory at Birmingham, for the purpose of having some dishes made for the Calotype process, which I was then working; and from what I then saw I was greatly impressed with the idea that papier-mache must shortly, to a great extent, take the place of wood, metal, and earthenware. Messrs. Jennings & Betteridge made me some excellent trays up to 15 × 13 inches, and these (with the exception of two which have been broken by falling on a stone floor) are now in use. As most of your readers are, no doubt, aware, papier-mache articles are made by two processes, the one being paper pulp cast in moulds; the other of sheets of paper pasted together, and, while damp, pressed into shape. Tea trays and similar articles are made by the last method. On removal from the moulds the articles are stoved under a considerable amount of heat (after having been colored and varnished), and this process renders them rather brittle.

The material may be used for many purposes after being simply dried, and in that state it is very strong and durable; it is not, however, waterproof, but this defect may be easily remedied by coating with shellac varnish, or, if preferred, by painting and polishing in the same way as the panels of carriages are done. The latter process not only renders them waterproof, but they resist the action of nearly all the chemicals used in photography. Concentrated cyanide is almost the only thing I am aware of which will act injuriously, and that only to the extent of dulling the varnish. The material, after simply drying, is capable of being planed, turned in a lathe, screwed, and dovetailed, and it decidedly has the advantage over wood, both as respects strength and lightness. I have some pieces nearly an inch thick, and as hard as a board.

If some of my readers are camera makers, I should strongly recommend them to make a trial of the Willesden paper, which I imagine comprises all the good qualities of papier-mache, with several others in addition; and I feel assured that the result will be very profitable. At any rate, it will not waste much time nor money if unsuccessful. There is another advantage I have forgotten to name, which is that the paper is not liable to warp, and slides for plate holders made of it are not likely to stick fast, as wooden ones frequently do.—*Year Book of Photography.*

IDLE STEAMSHIPS.

ALTHOUGH this should be one of the periods of the year when the employment of steamships ought to be at its highest, yet there are now, says *The Engineer*, about forty steamers laid idle in the Tyne, in addition to numbers in other ports. Generally, the idle steamers in the Tyne are of medium size—one or two being as small as of 500 tons gross register, but most of them varying between 1,000 tons gross and 3,000 tons. In nearly every instance they vary from five to eighteen years old, and may be said to be almost exclusively steamers with compound engines. In other words they are of a type which does useful work, but cannot do it in competition with more modern vessels in times like the present of very low freights. Between 60,000 and 70,000 gross register tons of steamers are thus lying idle at the one northern port named. But, in the meantime, it is a startling fact that, in one port alone, about £500,000 ($2,500,000) of British capital and possibly 700 men are thus laid idle now.

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMICAL.—Signaling to the Planets.—An interesting paper by Sir Robert S. Ball, LL.D., F.R.S., Astronomer Royal for Ireland. 13106

II. ELECTRICITY.—Electrical Horse Power.—A full article on the calculation of electrical horse power.—Formulas and examples. 13101

III. ENGINEERING.—The Washington Street Tunnel, under the Chicago River, Chicago.—3 figures. 13096

A Review of Marine Engineering During the Past Decade.—A paper read before the Institution of Mechanical Engineers.—By Mr. ALBERT BLECHYNDEN, of Barrow-in-Furness.—Treating among other subjects of forced draught, the construction and management of boilers and engines, piston valves, valve gear, crank shafts, and pumps. 13095

The Raising of the Utopia.—A brief account of the raising of the Utopia, which was sunk in the Bay of Gibraltar.—1 engraving. 13097

IV. GEOGRAPHICAL.—On the Coast of Labrador.—An account of the journey of Prof. ALBERT S. BICKMORE, of the American Museum of Natural History, N. Y., giving a full account of some of the peculiarities of that country. 13101

V. MECHANICAL.—Moulding Machine for Moulding Loam or Sand by the Aid of Striking Boards of Cylindrical, Elliptical or Irregular Forms. A full description of a machine especially adapted for moulding fly wheels, drums and rope pulleys in two or more parts.—2 engravings. 13101

VI. MEDICINE AND HYGIENE.—The Progress of Medicine.—Extract of an address by Dr. LAUDER BRUNTON on twenty-five years of medical progress before the British Medical Association, touching on advances in knowledge and teaching due to experimental method.—Influence of Darwin.—Changes in medical students.—Nature of fever.—Chemical and biological views of fermentation.—Microbes and enzymes.—Microbes and disease.—Struggle for existence between microbes and the organism.—Gains by experiment on animals, etc. 13103

VII. MISCELLANEOUS.—Amateur's Way of Rooting Cuttings.—A brief but instructive article, illustrated by 1 engraving. 13106

Is Wild Parsnip Really Poisonous?—An article by FREDERICK B. POWER, Madison, Wis.—2 engravings. 13106

Odorous Woods.—An extended paper by JOHN R. JACKSON, Curator of the Museums, Kew. 13105

Gum Arabic and its Modern Substitutes.—A paper read before the Society of Chemical Industry, London, by Dr. S. RIDEAL and W. E. YOULE.—With nine tables, setting forth the composition and characteristics of the gums. 13107

The Microbes of the Soil.—An interesting paper on microbes and organisms found in the earth.—Illustrated by 2 engravings. 13102

VIII. PHOTOGRAPHY.—Willesden Paper for Photographic Use.—By BAYNHAM JONES.—A brief description of a paper well adapted to the construction of camera boxes and other apparatus used by photographers. 13110

IX. TECHNOLOGY.—Musical Instruments—their Construction and Capabilities.—The third lecture of a course delivered by A. J. HIPKINS, F.S.A., before the Society of Arts, London.—An interesting historical sketch of the piano, showing its development from mediæval instruments. 13097

Asphaltum.—An interesting paper, taken from a census bulletin, relating to mineral industries, giving a full account of asphaltum and allied minerals. 13099

A Substitute for Glass—A description of a new invention of Friedrich Eckstein, of Vienna, Austria.—1 engraving. 13100

Warp Sizing, Drying, and Beaming Machine.—A description of a machine made by Messrs. Whitney & Sons, Prospect Ironworks, Lockwood, Huddersfield.—Illustrated by 1 engraving. 13100

The Preparation of Sirups.—A brief paper, giving valuable information on the preparation of sirups. 13110